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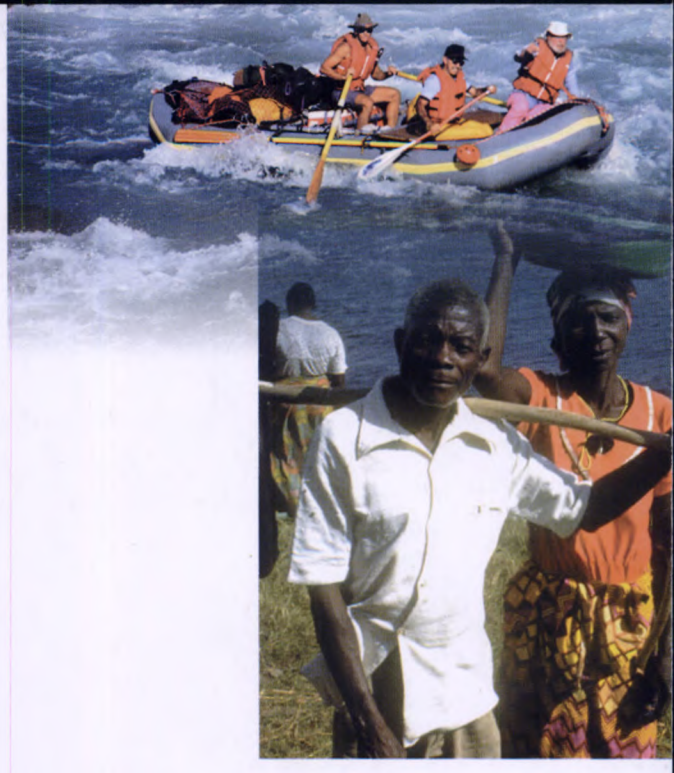
Vision for Water and Nature

Compilation of All Project Documents

A World Strategy for Conservation and Sustainable Management of Water Resources in the 21st Century



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This publication has been made possible in part by funding from the Global Environmental Facility.

Published by: IUCN Canada Office and Gland, Switzerland

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Citation:
IUCN (2000). Vision for Water and Nature. A World Strategy for Conservation and Sustainable Management of Water Resources in the 21st Century – Compilation of All Project Documents. IUCN, Gland, Switzerland and Cambridge, UK. viii + 224 pp

ISBN: 2-8317 -

First Edition 2000
Second Edition 2000

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Vision for Water and Nature

"FOR MANY NATIONS TODAY, SECURITY CONCERNS CENTRE LESS ON BOUNDARIES AND EXTERNAL MILITARY MIGHT THAN ON INCREASING CONFLICTS STEMMING FROM POVERTY, DISPLACED PEOPLES, ECONOMIC INSTABILITY AND COMPETITION OVER SHARED RESOURCES. THESE CONFLICTS ARE MAJOR ISSUES AND ALL OF THEM ARE ENVIRONMENT RELATED... THOUGH THE ENVIRONMENT TODAY IS A CAUSE OF POLITICAL TENSION AROUND THE GLOBE AND WILL LIKELY BECOME A SUBSTANTIAL SOURCE OF CONFLICT IN THE YEARS AHEAD, THERE IS ALSO EVIDENCE THAT THE EQUITABLE RESOLUTION OF RESOURCE DISPUTES CAN HELP PROMOTE WIDER PEACE AMONG NATIONS."

HER MAJESTY QUEEN NOOR OF JORDAN,

PATRON OF IUCN

A Vision is presented here of a world in which the benefits of freshwater and related ecosystems to humankind are optimised, while the intrinsic values of these systems are respected and preserved. In this world, the mutual dependence of people and ecosystems is accepted, and unavoidable loss of ecosystems' functions and biodiversity is more than compensated through restoration.

This Vision describes a world in which environmental security is guaranteed because everyone values and accepts personal responsibility for the conservation and wise use of freshwater and related ecosystems. The maintenance of environmental security is based on integrated management of all land and water use through an ecosystem-based approach within river and drainage basins, including their associated marine and coastal zones.

A World Strategy for Conservation and Sustainable Management of Water Resources in the 21st Century

It is also a world in which social security is strengthened by providing everyone with equitable access to and responsibility for safe and sufficient water resources to meet their needs and rights, by means that maintain the integrity of freshwater and related ecosystems.

Finally, it is a world where ecosystems are managed and used in a fair and equitable manner for economic security. Efforts are made to rectify and reverse existing trends in demographics, consumption patterns and human-nature relationships, in order to ensure that the current and future demands for water resources are realistically achievable without compromising the ecological, biological and hydrological basis and integrity of freshwater and related ecosystems.

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Vision de l'eau et de la nature

Ce document présente une vision d'un monde où sont maximisés les bienfaits que procurent à l'humanité l'eau douce et les écosystèmes qui en dépendent, dans le respect et la préservation des valeurs intrinsèques de ces ressources. Dans ce monde, non seulement l'interdépendance des êtres humains et des écosystèmes constitue-t-elle un principe admis, mais les travaux de remise en état compensent largement la perte inévitable des fonctions et de la biodiversité des écosystèmes.

Selon cette vision, dans ce monde, la sécurité environnementale est assurée du fait que tout un chacun respecte et juge importante sa responsabilité de conserver l'eau douce et les écosystèmes qui en dépendent, et d'en faire un usage judicieux. Le maintien de la sécurité environnementale est le fruit de la gestion intégrée, dans les bassins fluviaux et hydrographiques (y compris les zones marines et côtières qui y sont liées), de toutes les utilisations des terres et de l'eau selon une approche écosystémique.

Stratégie mondiale de conservation et de gestion durable des ressources en eau au 21e siècle

Ce monde jouit également d'une sécurité sociale accrue. Par le biais de mesures de maintien de l'intégrité de l'eau douce et des écosystèmes qui en dépendent, chaque personne profite d'une part équitable d'un approvisionnement adéquat en eau salubre, qui lui permet d'exercer ses droits légitimes et de subvenir à ses besoins, et s'engage à être responsable de ces ressources.

Enfin, dans ce monde, les écosystèmes sont gérés et utilisés de façon juste et équitable aux fins de la sécurité économique. Des efforts sont déployés pour corriger et renverser les tendances actuelles en matière de démographie, de consommation et de rapports entre les êtres humains et la nature, afin de satisfaire de manière réaliste à la demande présente et future en eau douce sans nuire aux processus écologiques, biologiques et hydrologiques ni à l'intégrité de l'eau douce et des écosystèmes qui en dépendent.

Visión del Agua y la Naturaleza

Se ofrece aquí una Visión de un mundo en el que se optimizan para la humanidad los beneficios de los ecosistemas de agua dulce y otros conexos y al mismo tiempo se respetan y preservan los valores intrínsecos de dichos sistemas. En este mundo, se acepta la dependencia mutua de las personas y los ecosistemas y, con la restauración, se compensa con creces la pérdida inevitable de funciones y biodiversidad de los ecosistemas.

Esta Visión describe un mundo en el que se garantiza la seguridad ambiental porque todos valoran y aceptan su responsabilidad personal por la conservación y utilización razonable de los ecosistemas de agua dulce y otros conexos. Se mantiene la seguridad ambiental debido al manejo integrado de todos los usos que se le dan a la tierra y al agua gracias a una solución de ecosistemas que se aplica en las cuencas fluviales y de drenaje, incluyendo sus zonas marinas y costeras relacionadas.

Estrategia Mundial para la Conservación y Manejo Sostenible de Recursos Hídricos en el Siglo XXI

También es un mundo en el que se fortalece la seguridad social al proporcionar a todos acceso equitativo a recursos seguros y suficientes de agua así como responsabilidad por éstos, de modo que puedan satisfacer sus necesidades y derechos, con medios que conservan la integridad de los ecosistemas de agua dulce y otros conexos.

Por último, es un mundo en el que los ecosistemas se gestionan y utilizan de una manera justa y equitativa para lograr la seguridad económica. Se procura rectificar e invertir las tendencias actuales en demografía, pautas de consumo y relaciones ser humano-naturaleza con el fin de garantizar que la demanda actual y futura de recursos hídricos se pueda satisfacer de manera realista sin comprometer la base e integridad ecológicas, biológicas e hidrológicas de los ecosistemas de agua dulce y otros conexos.

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Foreword

This document contains all of the key reports generated during the development of the Vision for Water and Nature, the environment and ecosystems component of the *Vision for Water, Life and the Environment for the 21st Century*, generally known as the World Water Vision.

IUCN – The World Conservation Union accepted the leadership of the development of this Vision, which was the first meaningful attempt to fully integrate environmental issues into the development of a comprehensive strategy for water resource management at the global level.

The development of the Vision for Water and Nature came to a culmination with its official presentation to the world at *Water and Nature Day*, Sunday, March 19, 2000, during the Second World Water Forum in The Hague. Immediately following this Foreword you will find the opening address delivered by Her Majesty Queen Noor of Jordan, Patron of IUCN. This is followed immediately by the summary of the day's discussions by Sir Martin Holdgate, former Director General of IUCN.

The first document in this volume is the Vision for Water and Nature itself, which is intended to serve as a strategy for both *conservation* and *sustainable management* of water resources for the first 25 years of the new millennium. Instead of considering the environment as one of many water management sub-sectors, our consultations led us to emphasise the crucial role of ecosystems as the basis of our life support systems, without which environmental security, social security and economic security cannot be achieved and sustained. The subject matter treated in this document therefore goes beyond strict 'environment' or 'conservation' issues and works towards defining a new pathway for integrated and sustainable land and water resource management. It proposes that this form of integrated management can only be effective if it is fully participatory, involving all stakeholders, and if it encompasses the full geographic dimensions of catchments or basins, especially when these cross regional and national boundaries.We hope that not just the environmental community but women and men in their everyday lives can take ownership of this Vision and actively pursue it.

The process of developing the Vision involved background research and extensive consultations with a wide range of stakeholders , beginning in January 1999 and extending into early 2000. Key elements of this process included the preparation of three thought-provoking Discussion Papers, which in turn served as the focus for three thematic workshops held as follows:

- Freshwater ecosystem management and social security, Harare, Zimbabwe, April 1999
- Freshwater ecosystem management and economic security, Bangkok, Thailand, June 1999
- Freshwater ecosystem management and environmental security, San José, Costa Rica, June 1999

Consultations also included representation by environmental specialists at a wide range of meetings associated with the development of Regional Visions and the other Sector Visions, which together comprise the building blocks of the overall World Water Vision. Finally, comments on the discussion papers, the Water and Nature workshop reports and earlier drafts of the Vision were invited and received via a dedicated Internet site and discussion group and through a network of experts assembled by the World Bank.

Each of the three Discussion Papers is included as a separate document in this volume, followed by the pertinent Workshop Report, in the above order.

I encourage the reader to consider this material as it was intended – to provoke thought and discussion. The ideas contained herein are not meant to be definitive solutions but to lead the interested reader on the path towards reaching our vision of a world in which every human being accepts responsibility for conserving and caring for life-giving water resources and the freshwater ecosystems that provide them.

M. C. Mercer

Director, IUCN Canada Office

Project Director, Vision for Water and Nature

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Address

Her Majesty Queen Noor of Jordan
IUCN's Vision for Water and Nature
The Hague
March 19, 2000

Your Royal Highness,
Your Excellency,
Distinguished guests and participants,

It is a privilege for me to join you today, to address a crucial problem facing us all, the rapid depletion and degradation of our world's most precious resource – water. When I consider the crisis we are here to discuss, two images spring to mind. One we all share – the harrowing image of the flooding in Mozambique, where people were threatened first by a surfeit of water, and then by the greater threat of no clean water at all. There could have been no more vivid demonstration of the power and preciousness of something we so often take for granted.

The second image is a picture I saw recently, taken from aboard the Space Shuttle, showing a mighty river basin, utterly bone dry. We have often heard that the Great Wall of China is the only human structure visible from space with the naked eye. In fact, I have it on good authority that is a myth. But how much more sobering it is to think that it is not a human structure, but human destruction, that we can see. Through a combination of climatic change and human mismanagement, the damage to our rivers, the veins that carry the life-blood of our planet, is becoming glaringly clear.

We are witnessing the consequences of deforestation, of water pollution, and of greenhouse gases changing the climate of the entire planet, altering weather patterns so that more floods and droughts can be expected in the future. Nearly a quarter of the world's six billion people have no access to safe drinking water, while almost half lack adequate sanitation, with water-related diseases killing up to four million people a year.

Fifty per cent of all the wetlands in the world have disappeared in the last decades and more than 800 freshwater species are currently threatened with extinction. We are not just consuming water more rapidly than it is replenished. Our over-consumption is taking its toll on the ecosystems we depend upon.

As we destroy our environment, we also destroy the foundation for sustainable development of communities and societies. If humanity continues to misuse water resources, then individuals and societies will continue to suffer. Social and economic insecurity will come from severely degraded rivers, lakes and groundwater reserves. In times of scarcity, we see rising stress over water and water resources. The environment today is a cause of political tension around the globe and risks becoming a substantial source of conflict in the years ahead.

As so many speakers have stressed during this forum, if we do not change the way we manage the limited water we have, what is now a crisis will become a global disaster. But there is also evidence that the equitable resolution of resource disputes can not only help our environment and development, but can promote wider peace.

It is my privilege, as Patron of IUCN – The World Conservation Union, to present the Vision for Water and Nature, the environment and ecosystems component of the World Water Vision. The result of three years' work by the World Water Council, of which IUCN is a founding member, the World Commission on Water and the Global Water Partnership, the Vision is a major attempt to fully integrate environmental issues into water resources management, and constitutes a vital part of the World Water Vision's perspective for water, life and environment for the 21st century.

IUCN – The World Conservation Union took the lead in developing the Vision for Water and Nature, in consultation with many other organisations and individuals. Through papers, workshops, a dedicated internet site and discussion groups, the IUCN produced insights into freshwater ecosystem management for social, economic and environmental security. The result is a daring Vision for the next century that goes beyond environment and conservation. It defines a new path for integrated and sustainable land and water resources management.

But as things stand, the look ahead is bleak.

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By 2025, the world will need to make available 20 per cent more water to supply the extra three billion people expected on the planet. By then, one in every three people –mostly in developing countries– will struggle to find water just to drink and bathe, much less to grow food. Water abstractions are predicted to increase by almost 50 per cent in developing countries. And, in Europe, more than 40 per cent of all groundwater reserves will be polluted with nitrates and pesticides.

Over the past few days, we have been exploring the water needs of different regions of our planet.

As you may have heard in sessions yesterday, the situation is particularly harsh in the region I am most familiar with, the Middle East. Rivers and renewable underground sources now supply only about half the water the region needs.

In Jordan, where the average Jordanian has access to only 85 litres daily compared to 600 litres used by an American, Amman residents last year received piped water for just 24 hours a week, and some outlying towns had to manage on single weekly deliveries. In Damascus, water supplies were shut off last fall three or four nights a week and Egypt's rising food imports reflects its own water crisis. Israel, the Palestinians and Jordan together consume about 3.2 billion cu.m of water a year. But in a year of average rainfall, only 2.5 billion cu.m are replenished. In 1999, Israel's main reservoir, Lake Tiberias, dipped to the lowest point since the 1930s. In Gaza, according to the World Bank, each Palestinian now has access to less than 57 litres of water a day.

Northern Africa, the Middle East, southern Africa and parts of China and India could face absolute water scarcity within 25 years – less than 1,000 cubic meters of water per person each year. Latin America and most sub-Saharan Africa must boost water resources by at least 25 per cent within two decades or face the same fate. Some countries will have to undertake massive water development projects, which can be vastly expensive and carry huge environmental risks.

This is the future we face if things continue as they are. But it is a future that we intend to replace with our Vision for Water and Nature. There is no doubt that the world's water resources are at serious risk. But we do not have to accept it. Experiences around the world show that such a future is avoidable.

If we build on what we have already learned, on what we know of sustainable practices and conservation measures, we can realize the world we envision here today. But we will have to address some thorny questions first, questions about equity, tradition, and self sufficiency.

Those of us here, and conservationists around the world, have realized that clean water, ecosystems and human activities are not separate realms. If we can spread the idea that social well-being, economic stability and the natural environment are interdependent, and degradation of any one endangers of all three, even those who have not made the environment a priority will see that we can no longer overuse and misuse our water resources.

Keeping ecosystems alive should be a guiding principle in the decisions we make. This is of course no easy task. Different parts of the world have their own reasons for ignoring environmental needs. Wealth breeds indifference, while poverty breeds desperation.

In the developed North, abundance in both money and natural resources, insulates the inhabitants from the consequences of water wastage. In the developing South, where the worst natural shortages occur, poverty makes survival the priority and pushes environmental concerns to the fringes.

It is unfair to place the bulk of the burden of ecological preservation on those very countries already staggering under supreme shortages of resources, education, infrastructure, and money. We have to assure the preservation of ecosystems and biological diversity, yes, but we must also help secure the livelihoods of communities around the world.

And those who use the lion's share of the world's water must share with those who have less – they must share their resources, their expertise, and their understanding that the challenges faced in other parts of the world must be recognized as their own challenges as well.

Naturally, such changes require effort. They require raising the awareness of individuals and communities and equipping them with the practical tools to use water wisely. They require the development of knowledge and know-how, to experiment with new approaches in water management and apply them to other regions. They require resources to be allocated to support such experiments and keep improved management practices in place. And, finally, they require people.

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People have to be enabled to participate in making the decisions that affect their most fundamental needs. And for this reason I am delighted to see that the Forum organisation has sponsored the attendance here of about 450 participants from the global South, members of grassroots movements, youth groups, women's organizations, and representatives of indigenous groups. When the people – particularly women, who are absolutely pivotal in this regard – are given a stake in their own future, they will take responsibility and do what needs to be done, making changes that would be impossible if imposed by some higher authority.

In that spirit of initiative and cooperation, the Vision for Water and Nature proposes six goals that will lead us to a sustainable water world. We, as societies and individuals, must choose to:

1. Care for the planet's ecosystems by respecting, conserving and restoring the planet's freshwater resources;
2. Adopt an ecosystem-based approach within river basins for sustainable water resources management;
3. Empower people to establish participatory, equitable and responsible water use;
4. Create political will and good governance to facilitate wise water use and prevent water conflicts;
5. raise awareness and strengthen capacity to change human behaviour to reduce water consumption and waste and protect ecosystems;
6. develop and share knowledge and technology to improve water resources management.

All of these raise issues – of responsibility for these goals, of encouraging participation, and of effective implementation. And here, too, the Vision, can provide suggestions:

- Governments, both national and local, should institute participatory ecosystem-based water management;
- Governments and international financial institutions, such as the World Trade Organisation and the World Bank, should establish conservation incentives based on ecosystems' full economic, ecological, cultural and intrinsic values;
- National governments, working together or through the United Nations, must define rights and ownership for international and national water and land resources;
- Educational institutions and non-governmental organisations (NGOs) should take the lead in training community leaders;
- The private sector, municipalities, and individuals must take full responsibility for compliance with existing laws and ethical codes, and governments must enforce these in order that they have the strength of purpose that they need;
- Community-based groups and NGOs, with government support, must build and strengthen education and communications to involve the people in the process;
- Research institutes, universities, environmental NGOs (ENGOs) and the private sector must develop and exchange new ideas in the quest to preserve our water.

The Vision for Water and Nature is not a rule book, but a recipe for change, meant to inspire, not proscribe. Actions have to be adapted to local needs, abilities and opportunities. Different nations, cultures, peoples and institutions must be free to use different methods to achieve the vision.

Today, we will discuss the Vision and the actions it requires, and explore the viability of those actions around the globe. Some of the foremost experts in the world are here to contribute their ideas. And of course, everyone present in this room is invited to participate in the debates.

I would like to express my admiration to all those whose work over the last few years has given form to our Vision, and made this meeting possible.

Also, we thank the Council and the Dutch Government for hosting the 2nd World Water Forum and Ministerial Conference, and to all those who have given their support to the Vision process. And as Patron of IUCN I would especially like to thank Ms Yolanda Kakabadse, and the rest of the IUCN team, for their seminal efforts and ongoing hard work.

That hard work has gathered together an unprecedented coalition of the world's foremost experts on water management.

Our own bodies and our earth's surface are both about 70% water. Neither we nor the planet can survive without it. The link between us and it is ineluctable.

Water can be a source of life or of death. In my own region, it is a prerequisite for health, economic growth and development, but it is finite resource and a potential source of conflict. When we have enough, it can seem the most innocuous of substances, but, as we see in Mozambique, in excess, or especially as we are beginning to see around the world, in scarcity, it can be immensely powerful.

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The Holy Koran describes water as the wellspring of life; throughout history and in every religion, it has had mystical significance. But in our modern, commodified world, those connotations have been lost. That kind of reverence is the vision we must recapture towards our world's water. Out of that reverence will grow shared concern and willingness, and collaborative effort to move from vision to action. The images with which I began prove that we cannot compete with nature; we cannot even control it. But we can work with it, and with each other, to realize our dream of clean water, healthy ecosystems and prospering societies for all the peoples of the globe.

May your discussions, well watered with the ideas presented here, bear excellent fruit.

Thank you.

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Summary of Water and Nature Day

2nd World Water Forum
The Hague
March 19, 2000
Sir Martin Holdgate

Keynote address by H.M. Queen Noor, Patron of IUCN

Water and Nature Day was opened by Queen Noor, who delivered an eloquent and impressive speech.

Reactions to the Vision

Panellists: Delmar Blasco, John Briscoe, Geke Faber, Yolanda Kakabadse, Claude Martin

The first session concluded that the Vision was broadly accepted by the participants. The crisis is indeed real, and has started. We have to alter public attitudes to water, and make sure that its fundamental role as the resource at the heart of global life is recognized. Water can be a foundation for peace rather than a cause of conflict if it is cherished as an essential part of our life support system and managed for the common good. We have to persuade people that ecosystem health is the key to economic and social health.

But the key lies in linking Vision to Action. Water is an intensely political subject. Water action must involve all stakeholders, linking governments, NGOs, engineers, ecologists and local communities. We need joined-up thinking, and this means better communication. We need to get away from sectoral rivalry and recognize that we must have joined-up management. But we must be practical: integrated water management does not remove the need for specialists but rather demands that the various fields of expertise are harnessed effectively. The goal is a water agenda that is nature-based, managerially practical and socially compassionate. Finally, it was emphasised that the Vision for Water and Nature had to be joined up with the other Visions – notably those of Water for Food and Water for People – in an overall approach that works with nature and not against it.

Reactions to the diagnosis of degradation

Panellists: Maude Barlow, Chris Dickens, Ghaith Fariz, Maritta Koch-Weser, Cecilia Tortajada

The debate in the second session centred on the question of whether the downward spiral of degradation –the 'bleak diagnosis' –was correct. The conclusion was that such degradation was indeed occurring, impelled by poverty but with the poor as its principal victims. It was also clear that the problem was not lack of knowledge – poor people often understand the destructive impact of their actions – but expediency. At the global level the wastefulness of the situation was reflected by the high expenditure on disaster relief, as compared with limited investment In disaster prevention.

The session agreed that there was a need to help all of society – but especially the poor – by maintaining ecosystem functions which can often save money and supply irreplaceable resources. Sustaining wetlands is cost-effective and the goal should not be merely to maintain basic ecosystem functions but to optimize them as the foundation for sustainable water resource use. Engineering works are needed, but we must not seek to cure all ills by technofixes.

What about the solutions? The suggestions may be grouped under five broad headings:

- we need an urgent restoration programme –a wetland restoration decade –to reverse the results of years of degradation;
- we must value wetlands and the environmental services they provide properly, and make sure those values are injected into cost-benefit equations, and reflected in the prices charged to those able to pay for water services;
- governments must accept their inescapable responsibilities. They hold water in trust for their people, and must provide leadership. They should seek nature-based sustainable water management, should remove perverse subsidies and waste stated to cost some US$220 billion a year, and promote water conservation, research, education, and capacity building. It was suggested that the new South African law might be a model;

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• the private sector has an important role, but it must operate within the framework defined by governments as custodians of water resources. The private sector should always work in partnership with governments – but for such partnerships to be effective the public sector must itself work better. Globalization of industry should not be a threat if properly controlled;
• water trading should not be regarded as a 'silver bullet', but proper pricing can help conservation provided it is contained within an equitable overall policy.

Power to the people: broad perspectives of action.

Panellists: Moustapha Ould Abeiderrahmane, Gaétan Guertin, Reema Nanavaty, Ted Scudder, Jean-Yves Pirot

In the third session we recognized that major catchment management schemes like OMVS in the Senegal basin could provide useful lessons, and needed to be studied accordingly. The central issue in such schemes is likely to be how to balance the needs of people and of nature (a theme first elaborated in the World Conservation Strategy of 1980). Well managed schemes could meet the needs of nature as well as supply agriculture, electricity, and navigation. Controlled flood releases were cited as one way of helping to meet nature's needs. It is however imperative that people in the basin should understand how a scheme is to be operated – and they must obviously have warning of flood releases.

Clearly any large scheme must be environmentally sound and economically efficient as well as socially acceptable to the people within the river basin concerned. Good schemes should give security because they meet the needs for ecological sustainability, water supplies, food and energy.

All stakeholders must be involved, to provide knowledge, guide plans, define needs and secure sound management. At present some key stakeholders – notably women and the poor are often excluded and the consequences are damaging. The role of women as owners, users and managers of water must receive greater emphasis. Much more needs to be done in developing effective mechanisms for involving people in decisions about water basin and water ecosystem management, and this involvement needs to commence when plans are first formulated rather than when they are so well developed that those developing them are strongly committed.

NGOs have an important role in creating opportunities for participation, and in developing institutions and partnerships. But they must work within the framework of the societies concerned, with sensitivity to their values.

The Framework for Action

Panellists: Max Campos, Alfred Duda, Nels Johnson, Jim Lamb, Tabeth Matiza Chiuta

The fourth and final session was about the Water and Nature Framework for Action. The thrust of the draft framework was generally endorsed, but a number of additional points (some recapitulating discussion in the preceding sessions) were made.

Three general considerations received especial emphasis:

• first, the Vision for Water and Nature must be integrated into the broader Framework for Action that should emerge from the Second World Water Forum and Ministerial Conference so that sustaining ecosystems, providing food and supporting people in other ways are treated as components of one package and catered for by integrated catchment management. Nature issues must not be treated in isolation, or there is a real danger that they will be marginalized and receive at best cosmetic attention while traditional economic sectors dominate. We need joined up thinking and joined up management;
• second, this joined-up thinking and action must link what is done to implement the Vision and Framework for Action to what is being done under other international instruments, such as the UN Framework Convention on Climate Change and the Convention on Biological Diversity;
• third, any action plan must evolve. Wetlands and the nature they support are already in crisis, and climate change will exacerbate those problems: today's actions will certainly need to be supplemented by others. But it is crucially important that a start is made now with actions that are clearly both practicable and urgent.

The proposed Framework for Action has six principal sections. These were not challenged, but some supplementary actions were suggested under many of the headings. In the following summary, these are emphasised.

1. Care for and manage freshwater resources

The Framework suggests that this be achieved by (a) leaving enough water in ecosystems to provide for essential ecological services; (b) controlling pollution and waste; and (c) reconsidering infrastructure development. In addition it was suggested that we should:

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• operationalize integrated management of water resources within whole river basins, linking management of water to management of land;

• emphasise the importance of the upper parts of river basins, and especially mountain catchments, noting that people living in such situations are often poor and need help if they are to conserve ecosystem functions and prevent erosion;

• recognize the interlinkage between freshwater and marine systems by including inshore marine waters in catchment management plans.

It was also suggested that the World Commission on Dams provided a model on which other international approaches could be based.

2. Develop incentives for conservation based on the ecosystem approach

It was noted that the 'ecosystem approach' has been accepted as a guiding mechanism under the Convention on Biological Diversity. Four component actions are outlined in the Framework: (a) valuation of ecosystem goods and services; (b) local payment to accountable institutions for effective services; (c) reconstructing subsidies and taxes; and (d) innovative financing of sustainable catchment use and conservation.

It was agreed that under (a) the full value of water and water resources must be estimated, incorporated in economic analyses, and adduced in support of conservation. Ecosystem functions and services must be quantified and valued, and paid for by users (with support where necessary to assist users too poor to pay for the resources on which they depend). As additional actions:

• the costs of pollution should be internalized, through the application of the polluter pays principle;

• standards and codes of practice for sustainable use of water and wetland resources should he enforced, and safer substitutes for polluting materials introduced;

• perverse subsidies and incentives should be identified and removed;

• users of river basin functions should pay for the services they use, and a means should be found to transfer funds from downstream beneficiaries to the occupants of headwater catchments, and so compensate them for measures they undertake that benefit those downstream.

3. Empower people for responsible water use and conservation

The Framework suggested that this aim be achieved by (a) establishing public participation; (b) equitable sharing of water resources; (c) defining rights and entitlements of local groups; (d) giving local groups a share in ownership of water infrastructure and land; and (e) training leaders and community groups. In discussion it was agreed that:

• the process should address access to water, and ensure an equitable distribution of the right to extract and use it;

• public participation should begin when plans are first considered, not at a late stage when the proposers are already strongly committed;

• special emphasis should be placed on building the capacity to participate, especially among women;

• NGOs should be recognized as having a particular role in capacity building.

4. Ensure political will and good governance

It was agreed that this should be done by (a) persuading politicians to accept the responsibility to care for nature; (b) ensuring compliance with existing laws, regulations and ethical codes; and (c) properly implementing basin agreements and institutional reforms. In addition there was agreement on:

• the need to raise understanding of water and nature issues among political leaders and decision takers;

• the imperative of fighting corruption and inefficiency;

• the need to strengthen institutions for conservation and sustainable development in many governments;

• the need to promote international conventions and agreements, especially those relating to shared catchments and providing for an equitable sharing of the costs and benefits of using water and wetland resources sustainably.

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5. Promote behavioural change by increasing awareness and capacity

The proposal in the Framework that this goal should be pursued by (a) improving communications outreach; (b) formal education and training to enable people to act; and (c) exchange of experience, so favouring common approaches and capacity building, was accepted. In addition emphasis was placed on:

- the need to recognize that traditional uses of nature are often ecologically sound and flexible;
- establishment of the right of access by stakeholders to available information;
- development of public-private partnerships and broader stakeholder partnerships at an early stage in the development of plans for catchment management and resource development.

6. Developing, maintaining and exchanging knowledge and information

Five mechanisms are listed in the Framework, and were not challenged: (a) participatory catchment management and conservation, (b) defining and meeting ecosystem water requirements; (c) biodiversity and ecosystem monitoring and benchmarking; (d) maintenance and use of hydro-meteorological networks; and (e) development and application of appropriate technologies. In addition participants urged:

- more research on ecosystem function and associated ways of conserving it;
- work to establish and demonstrate the real economic value of wetlands;
- recognition of the value of traditional knowledge, and of the need to codify and apply it.

The meeting echoed several points made by Queen Noor at the outset. All sections of society must join in establishing the Vision for Water and Nature. It cannot be done by governments alone, by NGOs alone or by professions and citizen groups alone. There must therefore be interactive frameworks that fit national circumstances. But the challenge is one of the greatest facing the world community, because water is at the heart of life, and without water, development cannot proceed.

The final message is that we cannot compete with Nature: we cannot truly control Nature, but we can and must work with Nature.

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Preface

I am pleased and proud to present to you the Vision for Water and Nature, the environment and ecosystems component of the World Water Vision. It is a major attempt to fully integrate environmental issues into water resources management, and constitutes a vital part of the World Water Vision's perspective for water, life and environment for the 21st century.

IUCN – The World Conservation Union took the lead in developing the Vision for Water and Nature and worked with a large group of organisations and individuals to produce this Vision. From January 1999 until early 2000, extensive consultations with stakeholders took place. Three thought-provoking papers served as the focus of three theme workshops on freshwater ecosystem management for social, economic and environmental security. A dedicated internet site and discussion group yielded more inputs. Results from this process were provided to other fora and to the World Water Vision team, and vice versa. The result is a daring Vision for the next century.

This Vision goes beyond environment and conservation. It explores and defines a new path for integrated and sustainable land and water resources management. The people involved dared to look ahead at the conservation of nature and the sustainable management of water resources in the 21st century – a time at which, I hope, all inhabitants of this planet will feel responsible for their water and ecosystems; a time at which we all will acknowledge the crucial importance of ecosystems and act wisely to manage and conserve them; a time at which we will drink the water and think of the well-spring.

Ecosystems are our life support systems. They are the foundation for environmental, social and economic security.

The group consulted in this process shared ideas and experiences to create this Vision, and IUCN, together with members and partners, is dedicated to making it become a reality. Now, at the start of a new millennium, I hope the World Water Vision and this Vision for Water and Nature serve that same purpose: to inspire people to contribute their vision and their work. Freshwater and related ecosystems are the source of life and the responsibility of all.

Yolanda Kakabadse

President, IUCN-

The World Conservation Union

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Acknowledgements

The number of contributors to this document is so extensive that they unfortunately cannot all be mentioned here by name.

The core members of the Water and Nature team were drawn from all parts of the IUCN – The World Conservation Union network. These individuals worked to develop and implement the process, as well as to ensure that the environmental concerns were heard throughout the other facets of the World Water Vision: Malcolm Mercer, Project Director; Chris Morry, Project Manager; Ger Bergkamp, General Technical Co-ordinator; and Debbie Gray, Project Officer. This core team was complemented by IUCN professionals who led the development of certain themes within the Vision. These include Cristina Espinosa, Gabriella Richardson, Lucy Emerton, Andrea Bagri, Frank Vorhies, Rocío Córdoba, Hans Friederich, Tabeth Matiza Chiuta and Jean-Yves Pirot. Many others throughout the IUCN network played important roles in organising and attending the meetings, obtaining input from others, spreading the word and providing their valued advice.

We would like to extend our full appreciation to the authors of the background papers: John Soussan and Nick Emmel, University of Leeds, and Chris Howorth, ETC UK; Michael Acreman and Matthew McCartney, Institute of Hydrology (Wallingford); and Tim Swanson, Caroline Doble and Nathalie Olsen, University College London – for their quality publications and support throughout the process. Karel Mayrand provided pithy and succinct assessments of how well each Regional Vision dealt with the Vision for Water and Nature core messages.

The IUCN wishes to give special recognition and thanks to the Global Environment Facility (GEF) for its financial support in the development of the Vision for Water and Nature, and to Alfred Duda, in particular, for his helpful advice and dedication throughout. We also thank the World Bank as the implementing agency for the project, managed by Ariel Dinar from the Rural Development Department. The authors especially appreciate the constructive comments received from the many specialists within the World Bank family: Christophe Crépin, Tony Garvey, Guy Le Moigne, Rafik Hirji, Stephen Lintner, Tony Whitten, Fernando Gonzalez, Randall Purcell, Gayatri Acharya.

Others whom we feel deserve special mention include Constance Hunt (World Wide Fund for Nature); Dolf de Groot and Johan van der Perk of the International Center for Environmental Assessment for their efforts in producing the final document; Sheila Riordon for her writing and editing skills; and Bill Cosgrove and Frank Rijsberman of the Vision Unit for their patience and guidance through the World Water Vision process.

Finally, a great many people have devoted their time and energy to the development of this Vision. These people represent institutions ranging from international organisations and financing institutions to national governments, river basin organisations, academia, local NGOs and concerned individuals. The list of contributors is extensive and includes, among many others:

Marta Kaczuro-Kaczyńska, Biksham Gujja, Michael Oneka, Hans Van Damme, Wulf Klohn, Hillary Masundire, Wolf Krug, David Groenfeldt, Alpina Begossi, Zeria Banda, Andrew Bullock, Max Donkor, Fernando Eguren, Graham Jewitt, Greg Keast, Ken Mease, Johnson A. Oguntola, Phera Ramoeli, Munyaradzi Saruchera, Karen Frenken, Paul Maro, Kevin Veach, Sansanee Choowaew, Ashim Das Gupta, Atiq Rahman, Thierry Facon, Yu Xias Gang, John Graham, M. Zakir Hussain, Koh Kheng-Lian, Le Huu Ti, Sein Mya, Chanthavong Saignasith, Brad Smith, Rosemarie James, Wilas Techo, Apichai Sunchindah, Sorada Tapsuwan, Jeremy Bird, Domitille Vallee, Sandra Postel, Jos Lubbers, Bertrand Charrier, Danielle Hirsch, Grethel Aguilar, Maureen Ballestero, Manuel Basterrechea, Vera Bononi, Max Campos, Claudia Candanedo, Joaquin Chacón, Carlos De Paco, Luis Rolando Durán, Jorge Jiménez, Jon Kusler, Tetsuya Kusuda, Jean-Marcel Laferrière, Enrique Lahmann, Lekan Oyebande, Jucimara Ganzort Pereira, Álvaro Porras, Adam Rankin, Philip Reynolds, Mario Sagastizado.

While the sheer magnitude of contributions makes it impossible to individually acknowledge everyone who took time to comment on draft versions of the Vision or participate in workshops, and the thousands more who visited the website, expressed an interest in the process and supported us in spirit, we would like to thank each and every one of you for helping to make this truly a shared Vision.

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World Water Vision: Its Origin and Purpose

Over the past decades it has become gradually evident for those directly involved that there is a chronic, pernicious crisis in the water world. The participants in the 1st World Water Forum in Marrakech in 1997 called for a World Water Vision to increase awareness of the water crisis throughout the population and develop a widely shared vision of how to bring about sustainable use and management of water resources.

The World Water Vision draws on the accumulated experience of the water sector, particularly through sector visions and consultation for Water for People (or Vision 21), Water for Food and Rural Development, Water and Nature, and Water in Rivers. It draws on the contributions of regional groups of professionals and stakeholders from different sub-sectors that have developed integrated regional Visions through regional and national consultations in more than 15 regions worldwide. As the Vision developed and evolved, more and more networks of civil society groups, NGOS, women, and environmental groups joined in and contributed to the consultations.

The participatory process that led to the World Water Vision makes it special. Since 1998, about 15,000 women and men at local, district, national, regional and international levels have shared their aspirations as well as developed strategies for practical action towards sustainable use and management of water resources. The recent availability of Internet communications made such a consultation possible in the short timeframe. This is not an academic exercise. It is the start of a movement. Over the coming months and years stakeholders will develop action plans to implement the recommendations of the World Water Commission and the strategies presented herein.

The World Water Vision aspires to be an inspiration to women and men to overcome obstacles and achieve fundamental changes. Its message is for everybody, particularly for the leaders and professionals who have the power and knowledge to help people to turn visions into reality. It challenges those directly affected by the water crisis to initiate action and to call on their leaders to bring about sustainable water resources use and management.

The Vision recognizes that if sustainable water resources use and management is to be achieved, people's roles must change. The main actors will be individuals and groups in households and communities who, with new responsibilities for the use of water and water-related services, are part of a collective strategy. Public authorities will need to empower and support them, and carry out the work that households and communities cannot manage for themselves. Water sector professionals and environmentalists will provide these stakeholders with the information they need to participate in decision-making and help implement their decisions. All these groups working together can achieve this Vision.

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Key **Messages** and Actions Required

The current and predicted extinction of freshwater species and decline in ecosystems that are vital for our water resources destroys the basis for sustainable development of communities and societies. In the last century alone, more than 50 per cent of the developed world's wetlands have disappeared.

Ecosystems and the life they contain have a right to the water they need to survive, to preserve their intrinsic values and enable them to continue to provide goods and services to humankind.

If humanity continues to misuse and destroy water resources and the ecosystems on which these depend, individuals and societies will ultimately suffer social and economic insecurity engendered by severely degraded rivers, lakes and groundwater reserves, and will be confronted with increasingly serious conflicts in times of scarcity.

This is an unacceptable future. Experiences from around the world show, however, that an alternative is at hand. Building on known sustainable practices and conservation measures, human behaviour can be changed to realise the world vision presented here. This will require us to take immediate and effective actions:

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Executive Summary

A year of worldwide consultations, conducted by IUCN – The World Conservation Union, has led to the development of a Vision for Water and Nature. This is an integral part of a Vision for Water, Life and the Environment for the 21st Century (the World Water Vision).

The Vision

This document provides a fresh perspective on worldwide water resources management and use. It is a Vision for a world in which environmental, social and economic security are guaranteed by fundamental changes in human attitudes and behaviour towards freshwater and related ecosystems. Moving from a synopsis of current and predicted problems, the document presents a conceptual framework based on key human interactions with nature, followed by a comprehensive plan of action.

Degradation of ecosystems and water resources

Water, once revered for its life-giving properties, has become a commodity. All too often it is taken for granted and routinely exploited. Throughout the world, human use of water has already led to dried-up and polluted rivers, lakes and groundwater resources. Potable water is becoming increasingly scarce. By the year 2025, it is predicted that water abstractions will increase by 50 per cent in developing countries and 18 per cent in developed countries. Effects on natural ecosystems will be dramatic. In the past century, over 50 per cent of the world's wetlands have been lost. Of the more than 3,500 species currently threatened worldwide, 25 per cent are fish and amphibians. The inevitable result of further human abstraction of water on this scale will be degradation or complete destruction of the terrestrial, freshwater and coastal ecosystems that are vital to life itself.

The causes are many, and it is wrong to single-out one group and hold them responsible. We are all responsible. Growth in human populations, increasing consumption, infrastructure development, land conversion and poor land use, overexploitation of species and ecosystems, and release of chemical and biological pollutants into water, land and air all threaten the ecosystem functions that produce our freshwater resources. Societies seem to be incapable of developing coherent social and political responses to this unbound resource extraction and degradation. Declining resources and distinctly unequal access to the remaining resources form the basis for conflicts at all levels of society that are already showing signs in some places of erupting into violence.

This is an unacceptable future. However, experiences from around the world show that an alternative exists. Building on known sustainable practices and conservation measures, we can realise the Vision presented here.

We have a choice to make, and the time for action is now.

Ecosystems are the source of water and life

We need to recognise that social well-being, economic stability and the natural environment are interdependent. Degradation of any one of these worsens the condition of all three. To reverse this downward spiral in which we find ourselves, two fundamental concepts must be understood:

- Ecosystems have intrinsic values and provide essential goods and services;
- Sustainability of water resources requires participatory ecosystem-based catchment management.

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Actions for a sustainable water world

The Framework for Action found in the Vision for Water and Nature proposes six goals that will lead us to a sustainable water world. We, as societies and individuals, must choose to:

- care for the planet's ecosystems by respecting, conserving and restoring the planet's freshwater resources;
- adopt an ecosystem-based approach within river basins for sustainable water resources management;
- empower people to establish participatory, equitable and responsible water use;
- create political will and good governance to facilitate wise water use and prevent water conflicts;
- raise awareness and strengthen capacity to change human behaviour to reduce water consumption and waste and protect ecosystems;
- develop and share knowledge and technology to improve water resources management.

The strategy presented here builds on important international agreements, and is supported by the identification of specific goals, targets and activities. This strategy is not a prescription, but is intended to assist in bringing about change. Different nations, cultures, communities, people and institutions will have to employ diverse sets of actions to bring about desired changes.

There are many activities that are recommended as part of the six goals described above. It goes without saying that there are also many individuals and groups who will have a role to play in these activities. Here are a few of the activities that demand priority, along with an indication of the groups that are most directly implicated:

- governments, both national and sub-national, must institute participatory ecosystem-based catchment management and all sectors and interests must take active part in these processes;
- international trade and financial institutions, such as the World Trade Organisation (WTO) and the World Bank (WB), as well as governments at all levels, must establish incentives for conservation based on ecosystems' full economic, ecological, cultural and intrinsic values;
- national governments, working hand-in-hand and, as appropriate, through the United Nations, must define rights and ownership for international and national water and land resources;
- educational institutions and non-governmental organisations (NGOs) must take the lead in training community leaders;
- institutional reform, nationally and internationally, must be given priority by all those who have the power to effect such reforms, guided and encouraged by the public at large, who will benefit most directly;
- private sector corporations, municipalities, private land-owners and individuals must take full personal responsibility for compliance with existing laws, regulations and ethical codes, and governments must be vigilant to enforce these in order that they have the strength of purpose that they need;
- community-based groups and NGOs, supported by governments and educational institutions, must build and strengthen education and communications to bring about appropriate behavioural changes;
- research institutes, management agencies, universities, international environmental NGOs (ENGOs) and the private sector water management industry must develop, maintain and exchange knowledge and information for the sustainable use of freshwater and related ecosystems.

The purpose of this document is to provide a Vision for how water resources can be managed sustainably, and a way to make this Vision a reality. The current outlook for the health of freshwater and related ecosystems and availability of water is not good. But with commitment and effort, we can choose to follow a path towards sustainable water use and management in this new millennium.

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Part I The Vision

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Vision for Water and Nature

A Vision is presented here of a world in which the benefits of freshwater and related ecosystems to humankind are optimised, while the intrinsic values of these systems are respected and preserved. In this world, the mutual dependence of people and ecosystems is accepted, and unavoidable loss of ecosystems' functions and biodiversity is more than compensated through restoration.

A World Vision for Conservation and Sustainable Management of Water Resources in the 21st Century

This Vision describes a world in which ENVIRONMENTAL SECURITY is guaranteed because everyone values and accepts personal responsibility for the conservation and wise use of freshwater and related ecosystems. The maintenance of environmental security is based on integrated management of all land and water use through an ecosystem-based approach within river and drainage basins, including their associated marine and coastal zones.

It is also a world in which SOCIAL SECURITY is strengthened by providing everyone with equitable access to and responsibility for safe and sufficient water resources to meet their needs and rights, by means that maintain the integrity of freshwater and related ecosystems.

Finally, it is a world where ecosystems are managed and used in a fair and equitable manner for ECONOMIC SECURITY. Efforts are made to rectify and reverse existing trends in demographics, consumption patterns and human-nature relationships, in order to ensure that the current and future demands for water resources are realistically achievable without compromising the ecological, biologica and hydrological basis and integrity of freshwater and related ecosystems.

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World Water Day

From Wasteland to

Record Set in 2024 after 25 Years of

A worldwide record for water resources restoration was achieved last year. Through 25 years of concerted global effort and co-operation, by 2024 an area equivalent to the size of the entire Great Lakes basin in North America, and water courses equivalent in length to the entire Rhone and Rhine rivers combined, have been restored to full health throughout the world. UN Secretary General Maria Petrova says, "*This is the biggest achievement of the Water Resources Action Programme presented in 2000 and the subsequent actions that flowed from it.*"

These results contrast sharply with the increase in industrial, agricultural and household water requirements predicted at the beginning of this century. At that time, rivers were running sewers, entire species of fish were disappearing, and wells were drying up all around the world.

"*Imagine if you are seeing water use increases of 50 per cent and the level in your well is already falling more than two metres a year. In 2000, the loss of almost a thousand species of fish, frogs and snails was forecast,*" says Christen Andrews, Water Resources Specialist of The World Conservation Union. "*Today, water managers have demonstrated fundamentally different behaviour. They keep our rivers, lakes and wetlands alive.*"

What brought about this fundamental change? The historic achievement, announced earlier this week, calls for a review of the efforts leading to this success.

Caring for the water's wealth

At the turn of the century, environmental degradation led to a growing awareness among experts of the linkages between environmental degradation, economic instability and social insecurity. The World Water Vision process pooled experiences and knowledge from around the world and created a strategy for conserving the world's freshwater resources.

An area the size of the Great Lakes restored

This strategy came at the right time. People all around the world started to act for the conservation of their water and ecosystems. "*When I was at primary school we learned not to waste the water we have. This has guided me throughout my professional career. Care for the water wealth,*" says Timothy Mbeke of the Department of Water Affairs in South Africa.

Aware that top-down, sectoral, and purely technological solutions to the world's water problems were largely ineffective, people began working together. They restructured water management schemes – basing them on ecosystems' needs and the goods and services these provide. Women played an essential role, because of their direct concern and involvement in the majority of day-to-day water use issues. Now, the needs of communities are directly addressed as the basis for preserving the quantity and quality of water and fish in lakes and rivers.

Eventually governments at all levels, from local municipalities to international bodies, realised that only a holistic catchment approach to participatory integrated management of water resources would work. From there it was an easy step to recognise the necessity of incorporating all land and water issues into these planning frameworks – from forest practices in the uppermost limits of the watershed, to the coastal deltas, mangrove swamps, and estuaries, whose rich fisheries are dependent upon a clean and seasonally-varied regime of water flows.

Valuing ecosystems' benefits

The goods and services provided by ecosystems, such as clean water, fish and fuelwood, were assigned values equivalent to their true economic worth. This allowed conservation to be justified not only in ecological, cultural and intrinsic terms, but also on economic grounds. Tax breaks and compensation schemes supported environmental protection. These new incentives, together with public pressure, made industries reduce production costs and pollution by investing in cleaner technologies and reducing water use and effluents.

Guus Rietveld, a Dutch farmer with 150 hectares of agricultural land, remembers the large investments he made to get to the close-to-zero-emissions levels required today. "*We had to combine the latest technology with innovative ideas. But we were able to cut our costs dramatically, which allowed us to invest in new ways of production.*" Today, domestic

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Wetland: Collaborative Efforts

and agricultural effluents are controlled and purified through various means, including artificial wetland systems and vegetated buffer strips along riverbanks and lakeshores.

Another industry that has gone through a major reform is construction. Today, the planning of dams, dikes and roads is based on reduction of environmental and social costs. Pressure from environmentalists and community groups, combined with a greater willingness of the industry to change, brought about this practice. In the last 25 years, annual construction of new dams has decreased by 83 per cent.

Empowering people for conservation

The key to success of the last decades lies in co-operation. A central element of the World Water Vision's strategy was the empowerment of individuals – of men, women and children representing all ethnic groups and social classes. Without equal rights to, access to, and control over water and land resources, inequity and conflict would continue.

"Our rights are now defined and we have clear agreements on fishing in the lagoon," says Vietnamese fisher Thi Thanh Thuy Dinh. *"We are prepared to work hard to keep our lagoon alive."*

Poor governance and lack of political will were some of the major obstacles to this change. Recall that it was only twelve years ago last week that tensions over disputed water rights in the Jordan valley erupted into bloodshed before cooler minds finally prevailed. Civil society played a major role in overcoming political reluctance to act. Grassroots initiatives demonstrated to

Success Story in the Sahel

Early on a February morning in the year 2025, on a vast floodplain of the Sahel, Ibrahim Diaw leads his herd of long-horned cattle to their dry-season pastures. He watches the animals closely with squinted eyes and with soft calls he urges them on. The grazing routes for nomadic herders are based on the ecosystem restoration programme initiated at the turn of the millennium. Using these migration pathways no longer results in violent conflicts with farmers, as was the case forty years ago after intensive irrigated rice schemes were constructed throughout the plain. Now his herd prospers through access to large expanses of restored perennial grassland, including those of the new Wahta Biosphere Reserve. Throughout the wet and dry seasons, water holes provide drinking water for his animals and the floodplain 'works' for the benefit of Ibrahim and the local people. They can now count on stable livelihoods based on recession agriculture, semi-intensive production, and artisanal and small-scale fishing. Ibrahim walks in the grass and thinks of the past – desiccated flats, 25 years without a single wedding in the village, his father who thought that they had been forgotten by God... He thinks that efforts to mitigate the impacts of infrastructure development are about to pay off: the dikes have been put to good use, artificial flooding schemes are effective and water is no longer wasted. Ibrahim's floodplain is alive and its water resources are used wisely.

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"Adaptive solutions have been the key"

governments what could be done through simple cooperation. Public pressure made them build on these extensively. Today, private and public institutions are accountable, and are oriented towards the local delivery of services and conservation of ecosystems.

Educating for change

The biggest and least visible change of the last 25 years has been in our attitudes, beliefs and fundamental values. Advocates at all levels have facilitated change through innovative education and communications programmes. *"Change the way a person thinks, and you change the world,"* to quote Mohammed Al Azra, the 'Water: Our Wealth' campaign leader.

Community-based awareness-raising programmes, such as 'Water: Our Wealth,' have dramatically increased public understanding of the need for ecosystem protection and sustainable water use. Continued investments in primary and secondary education ensure more equitable access to knowledge. Schools, universities and training institutions have incorporated interdisciplinary programmes for environmental appreciation and conservation into their curricula. In many countries, understanding of ecosystems is now common among the majority of resource managers and policy makers.

Information to innovation

One of the pillars of the water management success has been the gathering and sharing of information. Communication technologies had a tremendous effect on the way water resources information and knowledge were distributed and used. International, regional and national databases and information clearinghouses established at the beginning of this century have contributed greatly to the spread of information on environmental water issues. For example, the creation of the ABIS (Aquatic Biodiversity Information System) global geographic database in 2006 provided a powerful common source of reliable information in graphic form, depicting losses and preservation of aquatic biodiversity. As an information tool, this was in no small measure responsible for energising the global community to stem the calamitous decline in aquatic biodiversity that was taking place at the turn of the century.

People at all levels have been empowered as they gained access to these information sources. Scientists in many developing countries generated major innovations and have decreased their reliance on technical expertise from developed countries. A dialogue was established between scientists and holders of traditional knowledge, which now forms the cornerstone of many innovative resource management practices. Drawing on both technological innovations and traditional knowledge, dramatic improvements have been made, for example, in the agricultural sector.

Contrary to what was believed in the early part of the century, genetically modified crops (GMC) have only been introduced on a small scale. The emphasis today is on crop diversity, with strong reliance on locally adapted indigenous varieties, appropriate cropping techniques, and soil and water conservation to increase food production. Cristina Gomez of BIODIVI Inc. puts it like this: *"We never believed in GMCs, but have invested in research on local crop varieties that have adapted to more salty conditions and are naturally more resistant to pests and disease. Utilising simple cross-fertilisation techniques that would have been familiar to pioneer plant breeders one hundred and twenty-five years ago, we have been able to produce new varieties in only a few plant generations. These hydrids combine the salt- and disease-resistance of the so-called 'weed plants' avoided by farmers in the past, with the more highly productive features of varieties favoured in industrial-scale agriculture. We are now working with communities to grow these and sell them on the global market."*

"When I was at school, we learned not to waste water"

As a result of technological breakthroughs and public pressure, cheap and effective solar-powered desalination is now widely used in many arid and semiarid countries for domestic water supply. Irrigation is more efficient due to the growing use of automated, drip and subsurface systems. Industrial and domestic water reuse is now common practice, and non-water-based systems of sewage treatment and other methods of ecosanitation have been applied in many areas to reduce pollution and to make full use of human waste as agricultural fertiliser.

On the path towards sustainable development

Though last year's record restoration effort shows what can be achieved, there are still major hurdles to overcome. Contamination of water continues to be a major threat to the security of many societies. The clashes between the members of the Rhine River Board in February demonstrate that constant vigilance is needed to protect water quality, ecosystems and biodiversity.

Concerned citizens must continue to advocate change. Poorly-conceived economic incentives and a lack of political will still prevent some organisations and governments from following a sustainable development path. Says Hiroshi Yamanaka of Tokyo Management School: *"A lot has changed. But we still need major technological, social and financial investments to solve remaining water conflicts."*

At the turn of the century, the change in water management was begun. Social, political and technical measures were used in mutually reinforcing ways. And even though our freshwater can at times look troubled, the success of the restoration programme now shows we have taken that first important step down the path to sustainable development. ■

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2. The Problem: A Bleak Global Freshwater Outlook for 2025

2.0 Introduction

At the start of the new millennium, the world is faced with the certain realisation that, through unsustainable population growth, economic expansion and rising per capita consumption, humanity is finally reaching the limits of renewable water resources. No longer can engineering and technical solutions that characterised development and growth in the 20th century be depended upon to support further growth in population, consumption and improvements in the quality of life for the billions of people on the face of the planet. With increasing frequency, the freshwater and related ecosystems that supply and renew the water needed by humanity have themselves been degraded to the point that they can no longer support the diversity of life and life-giving functions they have always served. In addition, increasingly uneven distribution of and control over water resources is leading to a concentration in power, resulting in resources being controlled by fewer and fewer people. These ominous warning signs are ignored at all our peril. Humankind must now choose a new development path for water resources.

Fortunately, some positive developments that contrast with this bleak picture can also be seen, making it clear that it is possible to cope with population growth while meeting people's legitimate aspirations for a minimum level of secure livelihood. Many of these possibilities, however, are still on a local scale and have, until now, not resulted in a global change of direction. The Framework for Action (see Part II – Section 4) builds on these positive initiatives, and proposes a possible way forward that does not necessarily lead us down the path of widespread water resources degradation and conflict that is portrayed below.

Table 2.1 Water withdrawal by water use sectors as a percentage of total water withdrawal for 3 developing regions. Total water withdrawal for 1995 and 2025 is, respectively, 2,600 and 3,800 km³/year.

	1995: % of total use (2,600 km³/year)				2025: % increase/decrease compared to 1995 values			
	Agriculture	Industry	Domestic	Reservoir	Agriculture	Industry	Domestic	Reservoir
Africa	63.0	8.1	4.4	24.7	-15.7	+122.0	+36.4	-7.7
Asia	80.0	6.9	9.9	3.2	-10.0	+37.7	+53.5	+3.1
South America	58.6	17.2	15.4	8.7	-24.6	+31.4	+54.5	+12.2

Source: Shiklomanov, 1999

2.1 Developing world: Towards overpopulation and resource plundering

Population growth will remain an important driver of environmental degradation in the developing world. In most developing countries, population will continue to grow at a rate of 2-3%, with the result that 80% of the world population will live in these countries by 2025 (UNEP 1999). About 50% of these people will live in urban areas that are located mainly in coastal regions and near rivers, compounding the impacts on these ecosystems. Increasingly, westernised consumption patterns will aggravate the inequitable allocation of resources. Likewise, globalisation will contribute to inequity, as the greatest number of people will not benefit from investments in the global economy. A changing climate will start to affect many aspects of ecosystems, societies and economies as a rising sea level, for example, will affect many low-lying coastal areas through saltwater contamination of coastal aquifers and wells. The need to feed the world population will, in turn, lead to increased and likely more water-demanding agriculture, just as the need to produce more exports and compete in the increasingly global economy will accelerate industrial production (see Box 2.1).

The above factors will lead to greater pressures on freshwater and related ecosystems, mainly through increases in infrastructure development, water abstractions for agriculture, industry and municipal use, conversion of land for resource development, and pollution (see Annex 1). In China, for example, 6% annual growth is projected in spending on dams, mainly to provide hydropower. Total water abstraction for developing countries will increase by 46% to 3,800 km³/year by the year 2025 (see Table 2.1). Growing rates of population and industrialisation will cause domestic and industrial use to take up a larger relative portion of the extracted water, with most still being abstracted for agricultural purposes. More and more, crops such as cotton, flowers, bananas and soya beans will be produced for export. In many regions, surface and groundwater resources will be depleted due to increased irrigation for cereal and other food and forage crop production. In some regions, pressure to provide income-generating employment and to assist in the national balance of trade will lead to even further depletion of water resources to support unsustainable non-food agricultural production for export.

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Box 2.1

Conditions foreseen for Africa in 2025, given unabated water resources degradation.

Population growth is the main driver for change in Africa, followed closely by climate change. Acting together, they present a frightening future scenario. A reduction and higher variability in precipitation, deforestation and desertification are likely to increase scarcity of freshwater resources. By 2025, total water abstractions will have risen by 54% to 337 km³/year, agricultural use accounting for 53% of this. Expansion of irrigated land beyond the current 6% will cause further soil salinisation and waterlogging and, in many cases, a further loss of valuable wetlands.

Dam construction and disposal of untreated sewage and industrial effluents will increase sharply, for example, in the Senegal, Nile and Niger basins. Major threats to water quality are eutrophication, pollution, and proliferation of invasive aquatic plants like water hyacinth. Exploration of oil and gas fields forms a major threat in some areas (e.g. Niger delta, Lake Chad basin). In many African river basins, forest loss is very high (from 43 to 90% or more) and, if unabated, will dramatically affect the conditions in all major river basins. Groundwater resources comprise a major source of water for several countries, such as Namibia (40%) and Libya (95%), and will come under growing threat of overexploitation. Threatened biological diversity currently includes over 104 fish, 12 amphibian, 29 reptile, 53 bird and 89 mammal species, and these numbers will increase during the coming decades.

Most countries in North, Northeast and Southern Africa will face considerable water stress in the decades to come. Water resource degradation will fuel tensions between riparian states since most African basins are shared by two or more countries (e.g. the Nile and Okavango basins). The number of environmental refugees is likely to rise rapidly.

Sources: WRI et al., 1998; UNEP, 1999; Shiklomanov, 1999.

Increases in agricultural production will stimulate pesticide use. Together with sewage from cities that lack adequate treatment facilities, pollution of surface and groundwater systems will rise sharply. Further expansion of large-scale monocultures will push more farmers to convert natural ecosystems, such as upper catchment forests and wetlands, into agriculture production areas, inducing a severe degradation of water resources. In Southeast Asia and Latin America, for example, upper catchment degradation is foreseen to have severe consequences for the region in terms of flooding and reliability of water supply (see Boxes 2.2 and 2.3).

These augmenting pressures will induce a significant change in the state of many of the developing world's freshwater and related ecosystems. No longer will many of these ecosystems be able to provide goods and services essential for societies to survive (see Annex 1). Increased infrastructure development will alter timing and quantity of river flows, and block fish migrations. Overabstraction of water will lead to depletion of groundwater and biodiversity. Degradation of catchments will result in increasing erosion and flooding. Wetlands, dramatically reduced in numbers, will no longer provide flood abatement. The loss of species and habitats will dramatically reduce the world's biological diversity, and resulting declines in fish production will further exacerbate demands for protein from livestock production and agriculture. Most rivers will have become open sewers that no longer contain fish and other life forms, but transport pollutants to degraded coastal and marine ecosystems.

The impacts of continued water resources degradation are especially felt by the poorest people and nations. They will become more vulnerable to a wide range of fluctuations in the global markets. Poor nations and producers that profit little from global markets will see prices for many of their products fall further, forcing them to violate their land and water resources simply in order to survive. Floods and droughts also typically affect the poorest people most severely, as they often live in vulnerable areas and have no financial resources for avoidance, mitigation or adaptation. On the other hand, it must never be forgotten that floods do provide an essential service to millions of floodplain inhabitants. Their livelihoods depend on floods to replenish the soil and nutrients of the floodplains used in flood recession agriculture and for pasturage, and to clean and renew streams to permit fish passage for migration and the enhancement of fish production.

My vision is of access to good quality water for all people, all ecosystem services, and all ecosystems' survival, at all times, and for all resource needs (sectors, communities, agriculture, industry, etc.).

Atiq Rahman
Bangladesh

Social Security Workshop Chair

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Box 2.2 Asia

Projected 2025 impacts on Asian water resources, given a 'business as usual' approach.

Population growth will be a major factor in water-rich South and Southeast Asia. By 2025, this region, which comprises only 30% of the world's land area, will be home to 75% of the world's population. In the Mekong River basin, for example, the population is expected to almost double and, despite a projected 400% growth in the basin's economy by 2025, 70% of the population will continue to be rural and agrarian, requiring land to grow crops and water to catch fish. The tremendous biological diversity of Southeast Asia will be under greater and greater threat; already more than 216 fish, 47 amphibian, 104 reptile, 521 bird and 515 mammal species are on the brink of extinction.

By 2025, most parts of the generally parched West Asia will be desertified or threatened with desertification, leading to conflicts over water resources in such areas as the Euphrates and Tigris river basins. Soil erosion, salinisation, alkalisation and nutrient deposits will have a profound effect on land and water resources. Oil production will continue to cause major hydrocarbon pollution of freshwater and marine ecosystems.

In many coastal areas throughout Asia, seawater intrusion, new settlements, industrial growth, increased fishing pressure and reduction of freshwater inflow from rivers will cause major ecosystem destruction. Urbanisation will induce a rapid expansion of megacities that produce large quantities of untreated sewage. Energy demand is expected to have doubled by 2010. Dam construction for hydropower, domestic and industrial use and irrigation will sharply increase, pressuring freshwater ecosystems. Deforestation caused by logging and forest fires will increasingly threaten water availability and quality in many river basins, and high sediment loads will drastically reduce the lifetime of numerous planned reservoirs

Sources: WRI et al., 1998; UNEP, 1999; Shiklomanov, 1999; Witoon, 1999.

Box 2.3 Latin America

Latin America's water resources prospects for 2025, without intervention.

Latin America's development will be characterised by further expansion of megacities, in which 85% of the population will live by 2025. The large metropolitan centres will not likely be able to cope with the resource needs and waste production of households and industries. Currently only 2% of the sewage from urban centres is treated. Untreated effluents will cause major problems with water supply downstream, and proliferation of pathogenic diseases from pollution and vector-borne diseases from expanded reservoir construction is likely. Conflicts will arise at many levels, ranging from small upper catchments to large international river basins.

Based on an average South American deforestation rate of 3% (1990-1995), it is estimated that, by 2025, more then 50% of the current forest cover will be lost. Increasing evidence shows that deforestation and land conversion in Central America has severe impacts on the water supply, and aggravates the threat of landslides and mudflows posed by hurricanes and extreme precipitation. The effects of El Niño are also expected to become more extreme, leading to more frequent flooding during wet cycles and water shortages during dry cycles.

In Central America, the construction of small- to medium-size dams, which is projected to increase sharply during coming decades, is likely to affect freshwater biological diversity dramatically. Already 103 fish, 27 amphibian, 76 reptile, 353 bird and 263 mammal species are threatened. Mining is another major threat to water resources throughout Latin America. Past mercury emissions from gold mining, for example, were estimated at 5,000 tonnes for the period 1970-1995.

Sources: WRI et al., 1998; UNEP, 1999; Shiklomanov, 1999.

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Box 2.4

Despite progressive measures, continued degradation of European water resources is expected by 2025.

In Europe, overall consumption will increase and pollution-generating farming and industry will continue. The projected economic growth of 1.5% per annum will continue to exacerbate environmentally destructive practices. Public understanding of the role of the consumer society in degradation could, however, lead to more frequent and profound shifts in production methods. Water abstractions are projected to rise by 23% from 455 to 559 km^3 per year.

Dam construction is mainly considered for Spain and along the Donau. Other infrastructure development will continue, such as dikes and roads, although environmentally sound designs will more commonly be employed. Climate change is expected to lead to increased late-winter runoffs and reduced river flows in some of the main rivers, such as the Rhine basin. Overabstraction of groundwater resources will continue to cause falling groundwater tables that, in turn, will increasingly threaten critical ecosystems such as wetlands (e.g. in the Netherlands, Germany, Spain, Hungary, Slovenia and Poland). Already 60% of European cities are overexploiting their groundwater resources. Surface and groundwater pollution from nitrogen will remain problematic in the Northwest, and increasingly in South and Central Europe. Other pollutants, including pesticides, heavy metals and hydrocarbons, will also contribute to the poor water quality of most European rivers in 2025. Acid rain will continue to affect many water bodies in Central and Eastern Europe.

Falling groundwater tables will cause several agricultural areas to be taken out of production as aquifers run dry. Nitrate levels in drinking water will more frequently exceed international health standards in many countries. Investments in sanitation and soil and water reclamation will require major shifts in budget allocations and political priorities. The challenge for Central Europe will entail bringing together the industrial development needed for economic growth with environmental protection needed to maintain the water resources on which economic growth depends. The new European Water Framework Directive could be turned into the policy vehicle that is so needed for change to happen.

Sources: WRI et al., 1998; UNEP, 1999; Shiklomanov, 1999.

Increasing pollution from cities, industries and agriculture will take its toll in greater rates of illness and rising prices for safe drinking water and human health care. The loss of freshwater biological diversity directly threatens the economic basis of many societal groups, such as fishers and flood recession farmers, and indirectly affects whole societies by eroding the basis of essential ecological food webs.

2.2 Developed countries: Rising consumption and continued overexploitation

While population growth is low, overall consumption patterns and economic growth continue to act as major drivers for environmental degradation in developed countries. Increasing consumption and export is nurtured by a growth in agricultural production, which relies heavily on monocultures requiring large inputs of pesticides and genetically modified seeds developed by a small number of patent-holding monopolies. Corresponding increases in demand for industrial production perpetuate energy consumption that depends on fossil fuels, large-scale hydropower and nuclear energy, thereby offsetting anticipated higher material- and energy-efficiency of production.

In turn, expanding economies, consumption patterns and lifestyles will continue to place much pressure on freshwater and related ecosystems. Total water abstraction will increase by 17% to 1,400 km^3/year (see Table 2.2). To meet this demand, land will continue to be converted for agricultural, industrial and human use. Further dam construction for hydropower and irrigation will be limited to a few countries (e.g. Spain) since fossil fuel prices remain low, good new dam sites are rare, and public opposition to dam construction in most developed countries is increasingly effective at the political level. Insufficient investments are made, however, to remove existing dams and dikes, and to rehabilitate degraded freshwater and related ecosystems such as wetlands, floodplains and deltas. Surface and groundwater resources are rendered useless due to contamination with pesticides, manure, and nitrogen and phosphorus from fertilisers. Overextraction of water resources will continue in many regions, causing severe damage to natural habitats and aquifers, and causing seawater intrusion in coastal areas (see Boxes 2.4 and 2.5).

The augmenting pressures will affect the state of many of the developed world's freshwater and related ecosystems to the extent that they will no longer perform essential functions such as provision of clean drinking water (see Annex 1). In temperate areas connected to mountain regions, such as parts of northwest Europe and North America, increasing late-winter flooding is projected as a result of climate change. If greenhouse gas emissions remain unmitigated, temperature is expected to rise up to 7 degrees Celsius in some areas and rainfall is projected to change dramatically (see Figure 2.1).

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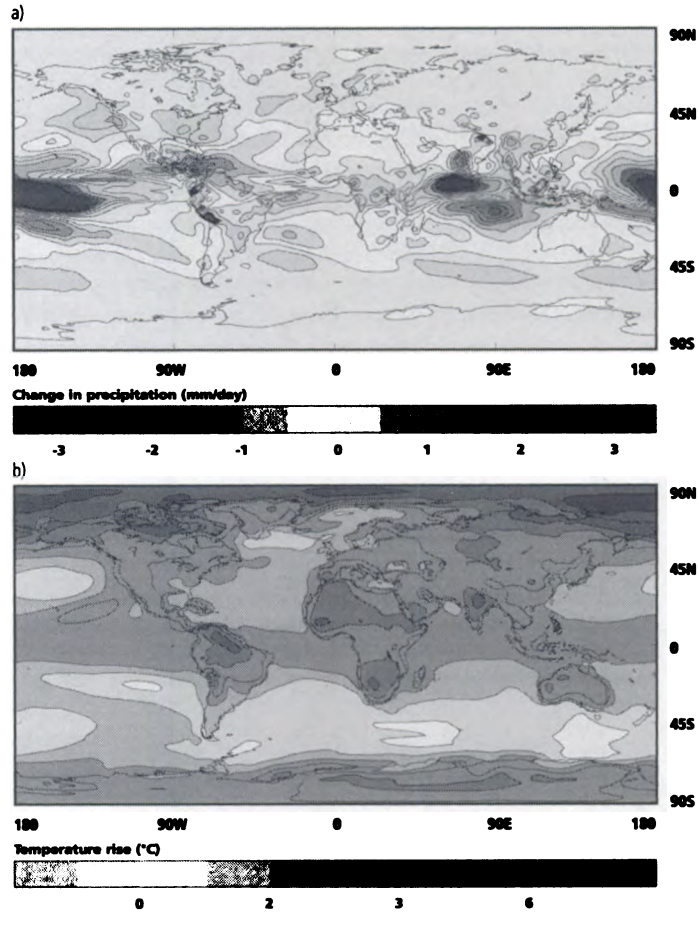
Due to the developed and new infrastructure, floodplains, disconnected from their rivers, will no longer be able to provide even minimal floodwater storage and peak flood attenuation. In the Rhine basin, for example, it is projected that flood risk to societies along the river will increase primarily due to continued expansion of urban and industrial areas into the floodplain, and that competing demands between industry, transport, agriculture and drinking water will make environmental conservation increasingly difficult. Agricultural, industrial and urban-based pollution will also increase the burden of disease and raise costs of clean drinking water and health care. In many areas, contaminated soils and sediments will continue to form chemical time bombs that pollute surface and groundwater resources for many years after their original release or deposition. Pollution will increasingly affect human and environmental health alike (see Box 2.5). Invasive plant and animal species will increasingly proliferate and affect waterways and bodies, disrupt entire ecosystems and cause a severe decline in freshwater biological diversity.

The decline of the state of many freshwater and related ecosystems will affect societies to such an extent that direct large-scale social and economic repercussions will be manifested (see Annex 1). For example, investments in water pollution abatement and control will likely double to US$ 250 per capita per year. Consumers, instead of polluters, will likely pay most of these costs. The destruction of natural freshwater habitats will also affect other economic sectors such as tourism. Increasingly, the need to reconcile the water requirements of different economic sectors will become the focus of water managers and other natural resource managers. Disenfranchised social groups and natural environments that are unable to press their claim for a rightful share, will be increasingly deprived of water if their requirements are not legally protected.

Figure 2.1 Global climate change predictions for 2080, resulting from scenario with unmitigated CO_2 emissions, showing (a) change in annual average precipitation, and (b) change in annual average temperature.



Reproduced with permission from The Meteorological Office, Hadley Centre for Climate Predications and Research (HCCPR, 1999).

Table 2.2 Water withdrawal by water use sectors as a percentage of total water withdrawal for 3 developed regions. Total water withdrawal for 1995 and 2025 is, respectively, 1,171 and 1,385 km³/year.

	1995: % of total use (1,171 km³/year)				2025: % increase/decrease compared to 1995 values			
	Agriculture	Industry	Domestic	Reservoir	Agriculture	Industry	Domestic	Reservoir
Europe	37.4	14.7	44.8	3.2	-0.5	-4.8	+2.2	-3.1
Northern America	43.5	10.7	41.5	4.4	-4.8	+15.0	-0.5	+9.1
Australia & Oceania	51.0	10.9	23.5	14.8	-8.2	+3.7	+11.1	+6.1

Source: Shiklomanov, 1999

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Given their economic and social advantages, developed countries will have much more opportunity to respond to the challenges of water resources management in the coming decades than countries in the developing world. Financial, technical and organisational capacity is the backbone of this enhanced potential. Improvements in water quality, for example, could be carried out in many developed countries by a combination of technical means and strict enforcement of existing regulations on effluent emissions. An exception is likely to be Persistent Organic Pollutants (POPs) derived from pesticides and herbicides, which will continue to be highly concentrated in many water systems. To improve riverine conditions, the upcoming relicensing of many dams will provide opportunities to establish more environmentally-sound dam operations or initiate dam decommissioning. Flood forecasting based on advanced technologies forms another example of how developed countries will be able to respond to increasing water resources pressures. However, a much more fundamental rethinking of water resources management is needed to improve the current situation.

Box 2.5 North America

World's highest per capita water use will continue to degrade North American resources.

North Americans will continue to use more water per capita than any other region, and population growth and higher living standards will continue to demand more water of good quality. Agriculture, power generation and domestic use are responsible for the majority of the water abstractions. By 2025, the total abstractions will have risen by 15% to 786 km³ per year. Climate change is expected to start to increase the demand for irrigation water.

Overextraction of the Ogallala aquifer, which supplies over 20% of U.S. irrigated land, will occur if projected use increases take place. The rising levels of pesticide and herbicide runoff and infiltration, together with heavy metals, will continue to pollute surface, ground and drinking water and increasingly affect human health and the environment. Already, in 1995, consumers were advised to limit their consumption of fish because of mercury, PCB and DDT levels that had risen by 14% over the previous year. Overfertilisation will cause greater eutrophication of water bodies and groundwater systems, causing a continued degradation of freshwater ecosystems, especially in the western coastal states and south/southeast of the Great Lakes region. Invasive species will increasingly infest waterways, and biological diversity will further decline. North America's freshwater animals are already the most endangered species group on the continent, dying out five times faster than those that live on land, with a rate similar to the loss of rainforest species. Since 1900, at least 123 species have been lost from North America's waters. A further 190 fish, 27 amphibian, 35 reptile, 84 bird and 94 mammal species are currently threatened with extinction, as 51% of species decline in numbers.

Dam construction is likely to be limited, and upcoming relicensing of dams will provide an opportunity to establish more environmentally benign operations. Investments in other water-related infrastructure could be implemented in more environmentally benign ways, but no clear trend has emerged so far. Resolving conflicts regarding the distribution of water rights, and the growth of municipal and industrial demands, will become a major challenge. Reconciling these with recreation, aesthetic enjoyment and wildlife habitat conservation will be progressively more important

Sources: Riccardi and Rasmussen, 1999; Shiklomanov, 1999; UNEP, 1999; WRI et al., 1998.

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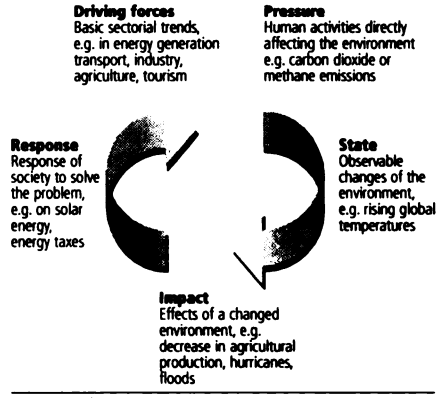
3. The Conceptual Framework: Human – Water – Nature Interactions

3.0 A pressure-impact-response model of water resources degradation

Sustainable development and caring for the earth form the basis of the Vision for Water and Nature. This implies ensuring that human development meets the needs of the present without compromising the ability of future generations to meet their own needs. It also means improving the quality of human life while living within the carrying capacity of supporting ecosystems. Economic, social and environmental components of the global system are intimately linked, and degradation of one component affects the conditions of the other two. Environmental degradation inevitably leads to a decline in social and economic security (see Annex 1). Loss of social and economic security, in turn, causes environmental degradation to continue, initiating a downward spiral of environmental degradation, poverty and social disruption. Understanding and accepting the mutual dependence between people and ecosystems forms the departure point for changing the ways that we manage water resources in the future.

Important drivers for environmental degradation are an unsustainable rise in world population and booming economic growth, which lead to increased natural resource consumption, social inequity and poverty. Resulting increases in the demand for water resources further pressure the ecosystems that provide this resource, through resource overexploitation, environmentally disruptive infrastructure development and water pollution. This continues to lead to the dramatic decline of the state of many of the world's ecosystems. Wetlands and upper catchment forests have disappeared, and the quantity and quality of many surface and groundwater systems is reduced and seriously degraded. People are more exposed to environmental hazards and, in many areas, experience water scarcity. Health problems and conflicts over limited resources erode the security of individuals, families and societies who, in response, either develop strategies to mitigate or adapt to the changes, or neglect them altogether. These drivers, pressures, states, impacts and responses provide us with a conceptual basis for unravelling the complex linkages between societal behaviour and either degradation or conservation of freshwater resources (see Figure 3.1).

Figure 3.1 Driver – pressure – state – impact – response model for understanding linkage between societal behaviour and the degradation or conservation of freshwater resources



Source: Jesinghaus, 1999

3.1 Ecosystems have intrinsic values and provide essential goods and services

To reverse the downward spiral of environmental degradation, people must first understand and appreciate the wealth that healthy, functioning ecosystems represent in the form of both their intrinsic value and the many socio-economic benefits they provide. These can be summarised as the range of functions (goods and services) that ecosystems deliver to humankind. These functions, which form the basis of the security of individuals and societies, include production, regulation, habitat and information functions. Lakes, rivers, and the coastal and nearshore marine ecosystems that form the highly productive link between the freshwater and marine environment, provide valuable fishing grounds and a major protein source for many societies. Upper catchment terrestrial ecosystems and wetlands regulate water quantity and quality by storing water, reducing sediment loads, and filtering and breaking down chemical and biological contaminants. Ecosystems provide habitat for fish, birds, amphibians and other organisms whose nurseries are essential to maintaining foodwebs that, in turn, form the basis of production. Tourism and recreational opportunities provided by ecosystems, such as rivers and lakes, often form an important source of local income and security (see Table 3.1; Annex 1).

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Table 3.1 Natural ecosystems provide many goods and services (functions) to humankind that are often neglected in (economic) planning and decision-making

1. Regulation Functions
The capacity of natural and semi-natural ecosystems to regulate essential ecological processes and life support systems

- Maintenance of biogeochemical cycling (e.g. air quality regulation and CO_2-buffering)
- Climate regulation (e.g. buffering extremes)
- Water regulation (e.g. flood protection)
- Water supply (filtering & storage)
- Soil retention (e.g. erosion control)
- Soil formation & maintenance of fertility
- Bio-energy fixation
- Nutrient cycling (i.e. maintenance of the availability of essential nutrients)
- Waste treatment (e.g. water purification)
- Biological control (e.g. pest control and pollination)

2. Habitat Functions
Providing refugia to wild plants and animals (and native people) in order to maintain biological and genetic diversity

- Refugium function (for resident & migratory species)
- Nursery Function (reproduction habitat for harvestable species)

3. Production Functions
Resources provided by natural and semi-natural ecosystems

- Food (e.g. edible plants and animals)
- Raw materials (e.g. thatch, fabrics)
- Fuel and energy (renewable energy resources)
- Fodder and fertiliser (e.g. krill, litter, etc)
- Medicinal resources (e.g. drugs, models, test organisms)
- Genetic resources (e.g. for crop resistance)
- Ornamental resources (e.g. aquarium fish, souvenirs)

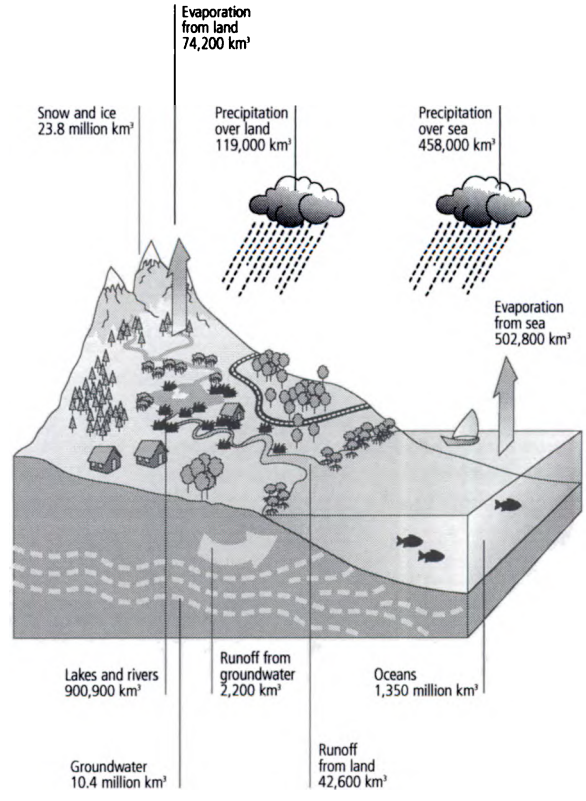
4. Information Functions
Providing opportunities for reflection, spiritual enrichment and cognitive development

- Aesthetic information (e.g. valued scenery)
- Recreation and (eco-) tourism
- Cultural & artistic inspiration (i.e. nature as a motive and source of inspiration for human culture and art)
- Spiritual and historic information (based on ethical considerations and heritage values)
- Scientific educational information (i.e. nature as a natural field laboratory and reference area)

Adapted from de Groot, 1992

Respecting the intrinsic values of ecosystems, and the benefits they provide, implies leaving water in ecosystems to maintain their functioning. This water, together with the water that is needed to meet basic human needs, is a reserve that has priority above all other water uses. Only water resources in excess of these basic needs should be thought of as 'available' for allocation to other uses. 'Water resources,' in the broadest sense, include water in all compartments of the water cycle, together with all the living resources this water supports, such as fish, amphibians and water flora. The interdependency of water cycle elements and processes, such as rainfall, evaporation, transpiration, and soil moisture, surface and groundwater, and coastal and marine waters, requires us to manage water resources within their basic hydrological units: the catchments and groundwater aquifers (see Figure 3.2).

Figure 3.2 General description of the water cycle.



Data from: Shiklomanov, 1999

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3.2 Sustainable water resources management through participatory ecosystem-based catchment management

To maintain the goods and services provided by ecosystems, water resource managers need to adopt an approach that treats water resources as an integral part of ecosystems; that is, as a limited natural resource, and a social, environmental and economic good whose quantity and quality determine the nature of its use. Such an approach has two fundamental requirements: (i) the management of catchments as an integrated ecosystem, and (ii) participatory planning and management. Water resources should be managed on the basis of river or drainage basins in an integrated fashion, with a continued and deliberate effort to maintain and restore ecosystem functioning within both catchments and the coastal and marine ecosystems they are connected with. A participatory catchment management approach addresses not only the issues of natural resources conservation and management, pollution control and sustainable agriculture, but also the concerns of governments, local populations, and their expert advisors. Through democratic, participatory planning and management, the ecosystem-based approach within catchments/river-drainage basins sets out an alternative to conventional top-down and sectoral approaches that fail to produce desired results and often lead to further environmental degradation.

Social, environmental and economic security are likely to be compromised by the transition of water as a freely available resource to water as a diminishing priced commodity.

Hillary Masundire
Botswana
Environmental Security Workshop participant

Why care for catchments or river/drainage basins?

Water and land use have reciprocal effects: land use depends on water appropriation, and the quality of freshwater ecosystems is directly affected by land use. Compounded by the stresses of population growth, global warming and deforestation, catchment degradation increasingly results in such extreme conditions as flooding and drought. The degradation of water resources cannot be addressed in isolation; rather, we must consider functioning of ecosystems simultaneously at different hierarchical levels, both in space and in time. That is to say, we must think about planning and management interventions at local levels (e.g. field, farm, village) as well as at regional levels (e.g. catchment and river/drainage basins).

Why participatory planning and management?

Catchment boundaries do not normally coincide with sociocultural and political boundaries, and catchments have therefore not generally been managed as a unit. Many human boundaries exist within and across a catchment, such as individual farms, villages, sacred grounds, ethnic groups and provincial boundaries. Given the 'mismatch' between a catchment perspective and socio-economic and political realities, it is important to involve stakeholders representing all views. Local communities, including men, women and children, provincial governments, technical institutions, non-governmental organisations (NGOs) and (in appropriate circumstances) donor agencies should work together on problem definition, planning and management of the natural resource base. In this way, global objectives of conservation, sustainable management and poverty alleviation are twinned with both local objectives and the development of locally-relevant adaptive management systems.

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Part II Framework for Action

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4. The Changes Needed

4.0 The choice we face: Neglect or care

In order to satisfy growing human and environmental water needs and rectify the destruction, degradation and pollution of ecosystems, a new strategy is needed. This strategy for a sustainable society should provide real improvements in the quality of human life, while at the same time conserving the vitality and diversity of ecosystems.

To achieve a sustainable society that cares for its resources, we must establish a fundamentally new paradigm for the use, development and conservation of water resources. This means establishing an ecosystem-based catchment management approach. It requires that we 'learn to care' about our water world; a world in which water resources will no longer be overused, but conserved and restored for the benefit of both natural ecosystems and humankind. In this world, more equitable distribution will bind people, societies and nations, reducing the schism between 'haves' and 'have-nots.' It envisages people-centred development that values both quality and quantity, that concentrates on equitable sharing, that recognises the need to maintain the diversity and productivity of ecosystems, and that values long-term sustainability above short-term revenue. Development and nature conservation are not opponents, but partners that must form a strategic alliance to create a sustainable water world.

Moving from this vision to action requires that we appreciate the intrinsic value of ecosystems and maintain ecosystems' abilities to provide goods and services to humankind. For this, we need to build on existing and new, predominantly small- and medium-scale approaches to sustainable water resources management. Based on local empowerment and adaptation to local conditions, these approaches maintain and restore the goods and services provided by freshwater and related ecosystems. Using soft engineering, appropriate technology, indigenous crop varieties and ecosystem-based management know-how, in combination with traditional and appropriate social and economic mechanisms, the security of communities and societies can be ensured while ecosystems are maintained and restored.

The vision and actions presented here build on important international agreements such as the World Charter for Nature, the Dublin Principles, Agenda 21, the Convention on Wetlands (Ramsar 1971) and the Convention on Biological Diversity (see Annex 2). A follow-up to these important international statements and agreements is needed as part of a renewed world effort to redress the continued degradation of water resources. Required changes are not cosmetic or short-lived; rather, they are fundamental and far-reaching, and will demand the full dedication of all nations and peoples.

The strategy presented here is not a prescription, but is intended to assist in bringing about change. Different nations, peoples, cultures and institutions will have to employ diverse sets of actions to bring about desired changes. Wealth, quality of life, and environmental conditions vary around the globe, and will continue to change over time. For this reason, the goals and actions described here are in broad terms, and the targets, rather than being defined in arbitrary numerical terms, reflect the general objectives of the vision. Each individual, institution and country will need to interpret and adapt these to local needs, abilities and opportunities. While diversity should be the basis for the world's path towards sustainability, one requirement is universal: *Joint action for ecosystem-based conservation of river and drainage basins, making a deliberate effort to profoundly reconsider our attitudes and behaviours towards water resources, their uses and their management.*

4.1 Caring for and managing freshwater resources in river or drainage basins

Maintaining the water resource base of our planet will require individuals to accept the duty of caring for other people and other forms of life, now and in the future. At its root, this is an ethical principle that requires us to respect the community of life, and share both the benefits and costs of water resource use and conservation. This ethic implies sharing water resources among different communities and interest groups, among people who are poor and those who are affluent, and between our generation and those who will come after us. It is a matter of both ethics and practicality to establish management for water resources that does not threaten the survival of other species and their habitats, but builds on their protection and maintenance. There are finite limits to the capacity of the earth's freshwater and related ecosystems[1] to withstand human abuse without serious and irrevocable deterioration. We must bring human population growth and our lifestyles into balance with nature's capacity and the limits of the renewable water resource base.

Participatory ecosystem-based catchment management

The interdependencies between land, water and segments of human society require NGOs, governments, local groups, private companies and donors, in consultation with stakeholders, to jointly develop and implement an ecosystem-based catchment management approach in order to sustainably manage water resources. The augmenting pressure of

1. Every action that takes place on land has an impact on the water resources of the catchment or basin in which it takes place. This is why a true ecosystem basis to freshwater resources planning and management is advocated, taking into account all land and water use at the catchment and basin level and related coastal and marine ecosystems.

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Box 4.1 Ecuador

Protection of 'cloud-forest' catchments to maintain the water supply of Quito city (Ecuador).

Protection of high-elevation forest, or 'cloud forest,' can augment water supply since water retained from condensation is as effective a water source as precipitation. The Nature Conservancy (TNC), the Ecuadorian Forest and Natural Areas Institute (INEFAN) and Quito's Municipal Sewage and Water Agency (EMAAP-Q), together with companies and local groups in and around Quito, recognise the importance of maintaining the catchments of the Quijos, Tumiguina and Blanco rivers, especially the upper catchment areas located within the Antisana and Cayamba-Coca ecological reserves. In 1998, a fund for the protection of the catchment was established. Water consumption fees will be negotiated with the various users to be directly invested in catchment protection to maintain water supplies and protect biodiversity, based on management plans to be developed during the coming years. This initiative exemplifies a collaborative effort to recognise the value of services provided by a protected catchment.

Sources: Hamilton, 1997; TNC, 1998.

increasing water demand and resulting conflicts, together with the greater variability and uncertainty in global environmental and hydroclimatological conditions, underline the urgency of establishing such an approach. The notion of participatory ecosystem-based catchment management incorporates the opportunities and limitations provided by ecosystems, societies and economies, rather than relying on conventional single-use, top-down planning and management.

In terms of nature conservation, this approach promotes the protection and rehabilitation of upper catchments, rivers, lakes, groundwater reserves, riparian zones, wetlands, floodplains, and coastal areas (see Box 4.1). This is not to be done in isolation of other catchment uses; on the contrary, biodiversity and environmental protection require the establishment of inter-disciplinary, intersectoral, and interinstitutional projects – both large and small – that develop strategies in a holistic way, building primarily on the needs of the catchment inhabitants. It comprises finding enough space for natural ecosystems, species and people, and restoring basic processes so that water moves through ecosystems with the appropriate flow regime, temperature and chemical composition.

This approach can truly be considered a 'paradigm shift,' and promising initial steps are currently taking place in many parts of the world. In Cameroon, for example, a floodplain is being brought back to life through the Waza Logone rehabilitation scheme. In 1978, a dam constructed for rice irrigation greatly restricted the seasonal flooding of the downstream floodplain along the Logone River, causing severe ecosystem degradation and the disruption of traditional livelihoods. In 1988, IUCN – The World Conservation Union initiated a project to rehabilitate the floodplain, including the 171,000 ha Waza Park. Pilot water releases through newly constructed openings in the main river levee have enabled restoration of approximately 60 per cent of the affected floodplain. The renewed flooding dramatically improved the living conditions for the people and their environment, without affecting the rice scheme. This ongoing project has already shown that ecosystem rehabilitation and water allocation for irrigated rice do not have to compete, but can exist side by side for the benefit of local people and ecosystems (Braund 2000).

Applying an ecosystem-based approach is a gradual process, since it takes time for farmers, fishers, women, youth and other potential users to conduct their own testing and adaptation before deciding whether to adopt such new approaches. Initial development and implementation of models may begin slowly, with a few cases of replication here and there, but there is bound to be an upsurge in acceptance as success stories abound. The green revolution took 30 years to show results (which were not all positive); participatory ecosystem-based catchment management cannot be expected to prove itself in a single project cycle of 3 to 5 years. Patience, along with proper monitoring and evaluation to learn how to care for and adapt to changing conditions, will be essential (see Box 4.2).

Leaving enough water in ecosystems to provide services

As the source of water and life, ecosystems must be protected and wisely managed by the industries, municipalities, households and farmers who rely on them. Some ecosystems, such as upper catchment 'cloud forests,' springs and certain wetlands, directly provide us with clean water. Other ecosystems contribute to the regulation of water resources, reducing flood peaks and removing chemicals (see Annex 1). Ecosystems need water to fulfil their basic requirements and maintain these functions.

To achieve this will entail users to leave the required amount of water within ecosystems, while achieving equitable allocation of the abstracted resources. By leaving enough water in ecosystems, biodiversity and key habitat characteristics can be maintained – including interconnections between channels and floodplains, and upstream and downstream areas, including coastal and marine areas. Techniques are increasingly available for determining the quantity, quality and seasonal flow regime required for maintaining rivers, lakes and coasts. These can be used to establish needed reserves of water; that is, amounts that cannot be taken from the ecosystem if it is to maintain key processes, habitats and species and continue to serve the vital functions upon which humanity depends.

A key element of the process of change is the promotion and establishment of actions at the community and local levels that empower individuals and communities and enhance socially acceptable rights, entitlements and access.

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Box 4.2 Australia

The Murray Darling Basin Initiative: The world's largest catchment management programme.

The Murray Darling catchment covers more than one million square kilometres – one-sixth of Australia – and includes 24 major rivers. Salinity is a natural feature of the catchment. The problem is that changes in land use and water use have intensified this aspect of the catchment, resulting in conflict with human and environmental needs. Removal of natural vegetation has altered the water balance of the land so that water tables have been rising, leading over time to salinisation of the soil. Saline inflows, in turn, affect river water quality, endangering important aquatic and riparian ecosystems as well as threatening domestic water supplies for the city of Adelaide and much of South Australia.

In recognition of this, and other problems in the catchment, the Murray Darling Basin (MDB) Initiative was established in 1987. The natural resources management strategy that deals with the management of the riverine environment, irrigated and dryland regions, and basin-wide issues, underpins the MDB Initiative. The riverine environment sub-programme covers three broad areas: improvements to water quality; river flows with respect to balancing human and environmental needs; and nature conservation. A salinity and drainage strategy has been proposed for irrigated regions. Through this strategy:

- Improved land management techniques are being introduced to minimise the amount of irrigation water being added to the water table. Through the use of new crops and more efficient irrigation technology, this will encourage the use of land within its sustainable capacity.
- Engineering works are being constructed to intercept highly saline groundwater and pump it to suitable disposal sites before it flows into the main river system.
- New operating rules have been introduced to reduce evaporation losses from reservoirs.

In addition, the MDB Initiative recognises the role of wetlands in enhancing river water quality, and a Floodplain Wetland Management Strategy has been developed that aims to maintain, and where possible enhance, the floodplain wetland ecosystems. Constructed wetlands are being specifically designed to reduce nutrient loads from farm runoff, sewage treatment, industrial plants and urban runoff.

Throughout Australia, Integrated Catchment Management and the Landcare system have encouraged farmers and other rural industries to work together with government and rural communities to solve a wide range of rural problems (Campbell 1994). The Landcare system combines elements of community and environmental education, action research and participatory planning. More than 2000 voluntary Landcare community groups are currently working to develop more sustainable systems of land and water use within catchments, supported by a national ten-year funding programme.

To leave water in ecosystems will, in many cases, require a reduction in the total amount of water abstracted from rivers and groundwater systems. Inevitably this will require a corresponding reduction in the water demands of agriculture, industry and direct human consumption. To reduce total human water demand requires both behaviour changes, such as reduced consumption, and technical improvements in water distribution, such as improved irrigation efficiency and water supply leakage reduction.

Controlling pollution and waste

Degradation of freshwater ecosystems and the resources they provide is due partly to pollution and waste disposal. In many catchments, pollution of watercourses and groundwater reserves needs to be controlled, from specific as well as diffuse sources. Municipalities urgently need to treat effluents from expanding urban areas. In the developing world, sanitation services and wastewater treatment within megacities should be given a high priority, as cubic kilometres of untreated and polluted discharge is threatening downstream ecosystems now and into the near future.

For industries need to reduce their effluents to acceptable levels, governments need to enforce regulations and provide incentives to companies to comply with national legislation. In many cases this can be achieved by developing more efficient production processes in which raw material use is reduced, and material cycles are closed, in combination with adequate residual effluent treatment. These strategies can provide huge opportunities to cut production costs, creating a win-win situation that should form the basis of sustainable industrial development.

Diffuse sources of pollution, such as agricultural runoff and infiltration, require tackling at the base. Farmers need to establish good land husbandry all across catchments in order to reduce agricultural runoff of sediments, fertiliser, pesticides and herbicides. An emphasis on the management and conservation of water and organic materials, both above and in the soil, forms the basis for achieving conservation of soil and water resources within the food production process. Together with a reduction of chemicals used for disease control (e.g. through integrated pest management), this will not only benefit farmers directly through increased production and reduced costs (e.g. fertilisers), but also provides benefits for all catchment inhabitants and ecosystems downstream.

Reconsidering infrastructure development

Sustainable water management requires a different approach to infrastructure development: an approach that 'lives with nature,' as opposed to one that 'strangles nature.' Leaving more space for natural ecosystems will require governments and developers to reallocate financial resources and redesign new or decommission existing infrastructure such as dams and dikes (see Box 4.3). Avoiding the huge environmental impacts of many infrastructure developments throughout the world will, in many cases, be much more profitable then paying for later repairs. Approaches to water management that take

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Box 4.3

U.S. Army Corps of Engineers to invest in environmental protection for flood control.

Flood-prone communities in the United States have welcomed the new approach taken by the Corps that focuses on flood mitigation and riverine restoration by, simply, getting out of the way. U.S. Congress allocated US$ 200 million to develop pilot projects, in addition to the US$ 533 million the Federal Emergency and Management Agency has already spent on a similar approach that involved removing over 20,000 structures during the last six years. The Corps will pay 65% of the cost of buying properties in floodplains, tear down structures such as dams and dikes, relocate property owners, and restore freshwater and related ecosystems. Already more than 100 communities have expressed interest in the programme, of which they have to finance 35%. The traditional Corps philosophy was always, "Deeper, straighter, wider; just to see how fast you could get the water out of the area", said Dennis Murphy, chairman of the Mill Creek Watershed Council, who is interested in participating in the new programme. If successful, the Corps pilot project could initiate a much larger long-term programme and a major change in water management culture in the United States

Source: Maddox, 1999

advantage of natural features of the ecosystem are therefore often much less costly than large-scale infrastructure developments.

In France, for example, the decommissioning of dams in the Loire catchment presented an opportunity to rejuvenate the riverine ecosystem. With the adoption of the Natural Loire River Plan in 1994, the French Government initiated the decommissioning of three dams on tributaries of the river. It concluded that the existence of the dams could no longer be justified since their ecological impacts were no longer compensated for by their economic return. The objective of their removal was to restore the riverine ecosystems and bring back the great Loire salmon, which is the only salmon in Europe still able to migrate over a distance of more than 800 km from the estuary to its spawning sites. In two cases, upon expiry of the dam licenses, the facilities were transferred back to the State which, between 1996 and 1998, had invested FF 6 million and FF 14 million, respectively, in their decommissioning. The third dam was decommissioned by Electricité de France for a total of FF 7 million in 1998. Decommissioning of dams is increasingly seen as an option to bring back the proper functioning of river ecosystems. In many countries, like France, the United States and Canada, the relicensing of a dam facility provides the opportunity to improve the dam structure to allow environmentally-appropriate flows, or to decommission the dam if environmental impacts are judged too severe (Delaunay 1999).

For new infrastructure developments, developers should integrate high quality environmental impact assessment (EIA) studies into the planning phase, not merely as an add-on to the project development. In this way, the results of an EIA can be directly linked to the design and implementation of avoidance, mitigation and compensation measures. For existing infrastructure, operators will have to comply with modern environmental standards that allow for environmental flows, establishment of migratory species passages, and compensation for affected habitats and species.

In 2025, ...

the basic needs of freshwater and related ecosystems are cared for...

GOAL	Critical freshwater and related habitats and species are protected through implementation of sustainable water and land resource use and control of pollution from agriculture, industry and domestic water use.
TARGET	Protection of majority of upper catchments, wetlands, rivers and groundwater reserves effectively implemented.

ACTIONS

- NGOs, governments, local groups, private companies and donors, in consultation with stakeholders, to jointly develop and implement well-monitored pilot projects on participatory ecosystem-based catchment management, and protect and rehabilitate freshwater species and critical habitats, such as upper catchments, river channels and banks, wetlands, floodplains and coasts;

- Industries, municipalities, households and farmers to implement water-saving measures to reduce water use and allow appropriate amounts of water to be left in rivers, lakes, wetlands and groundwater aquifers;

- Farmers, municipalities and industries to reduce emissions of nutrients, untreated effluents and hazardous waste through compliance with existing regulations and closing the material cycles, including resource-use reduction and waste (water) treatment;

- Governments to minimise dam construction and support decommission of non-efficient/high-impact dams; developers to optimise the design of new dams to allow species migration and mitigate other environmental impacts; and operators to change dam management practices to fulfil water requirements of all up- and downstream ecosystems.

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4.2 Incentives for conservation based on an ecosystem's full values

Sustainable water resources management requires us to recognise the range of goods and services ecosystems provided to humankind as well as the intrinsic value of ecosystems (see Annex 1). The goods and services ecosystems provide hold tremendous value, which needs to be reflected in water resources development schemes. Local governments and NGOs, together with resource managers and consultant agencies, must address these values and the high cost of degradation by reconsidering current subsidies which, by maintaining the status quo, are in fact a causative factor of degradation and do not contribute to sustainable development. At local levels, increased participation in water resources management could be twinned with increased financial responsibility. At catchments levels, innovative financial mechanisms need to be implemented to finance catchment-wide maintenance of ecosystem services and the implementation of conservation measures. A range of economic instruments will be needed to counter development practices that overexploit resources, pollute life-support systems and destroy ecosystems and biodiversity, based on proper analysis of values, rights and entitlements.

Valuation of ecosystem goods and services

The economic, ecological, cultural and intrinsic value of ecosystems' goods and services should be reflected in their use by people and the price institutions pay for use. Reflecting water's true value, without compromising people's rights to fulfil their basic human needs, will create an incentive to reduce use, degradation and pollution of water resources in many but not all parts of the world. It will require major changes in the ways costs and benefits of development schemes and infrastructure projects are calculated, including the full social and environmental costs. To enable this, resource managers, NGOs and consultant agencies will need to quantify the ecological, sociocultural and economic values of freshwater and related ecosystems as much as possible, and include them in the cost-benefit analyses of the planning process (see Box 4.4).

Methods for quantifying the full value of the goods and services of freshwater and related ecosystems are increasingly available, but need to be further improved. To know these values is one step; incorporating them in decision-making and management is an entirely different exercise. All countries, peoples and water users need to adopt economic, social, political and legal mechanisms to fully incorporate these values.

Local payment to accountable institutions for effective services

In some cases, an appropriate instrument would be for NGOs and local governments to work with local institutions to price available water resources, after the basic water needs of people and ecosystems are met. Water pricing should thus not be carried out for water quantities required for fulfilling basic human and environmental needs. It should, among other things, be based on progressive (block) tariffs and the polluter-pays principle. Water pricing, however, cannot be carried out without the development of a proper legal and institutional system that protects the voiceless and delivers the services.

At local levels, the capacity to pay is largely determined by the benefits that can be gained directly from payment. The willingness to pay increases significantly if payments are made to local institutions that can be held accountable for delivery of services. Participation of those who pay in the management of these local institutions is essential. If payment and delivery are twinned with trust and transparency, considerable progress can be achieved in local water resources management.

Box 4.4 Nigeria

Benefits from traditional floodplain use higher than large-scale irrigated agriculture in Nigeria.

Recent estimates of the value of Hadejia-Jama'are floodplain use in northern Nigeria indicate that traditional practices provide higher benefits than crops grown on the Kano irrigation project. Benefits derived from firewood, recession agriculture, fishing and pastoralism were estimated at US$ 12 per litre of water, compared to US$ 0.04 per litre for benefits derived from the irrigation project. This evaluation is particularly important for the region, as more than half of the wetlands have already been lost to drought and upstream dams. Even without accounting for such services as wildlife habitat, the wetland is more valuable to more people in its current state than after conversion to large-scale irrigated agriculture. This example shows that if proper cost-benefit analyses are made, which include the value of goods and services provided by ecosystems, then large-scale development schemes turn out to be less profitable than improving the management of the unaltered ecosystem.

Source: Barbier & Thompson, 1998

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Restructuring subsidies and taxes

Some existing economic policies and instruments stimulate freshwater ecosystem degradation, excessive water extraction and pollution through perverse subsidies, distorted prices and taxes. Governments will have to change these by developing new policies, guidelines and economic instruments that provide incentives for sustainable ecosystem-based management. Internalising the economic implications of ecosystem degradation and loss of environmental security from global to local levels is an important instrument for addressing these challenges. To resist overexploitation and ecosystem degradation, sufficient funding needs to be provided to face the effects of globalised markets. This will require more effective and efficient ways of financing development, conservation and restoration activities, including private sector investments.

In the United States, for example, investment in catchment protection is expected to save New York City billions of dollars. The city has set aside US$ 250-300 million for the acquisition of some 80,000 acres of land as part of an integrated strategy to protect water supplies from pollution. Watershed regulations are also being expanded to address related issues, such as the construction of impervious surfaces (e.g. roads and parking lots) close to reservoirs and watercourses, storm-water runoff, the unprotected storage of highway salt, and rigorous standards for sewage handling. Many of the city's 130,000 septic systems will be closed and strict standards will be set for the construction of new ones. Homes and businesses will be connected to newly constructed, city-subsidised tertiary treatment plants. Total investment in the strategy is US$ 1.5 billion; however, by protecting the water sources that supply New York from pollution, the city is able to avoid constructing a water filtration plant that would cost US$ 6-8 billion and would incur annual operating costs of $300 million (The Trust for Public Land 1998).

In order to realise the Vision, positive and enabling economic measures for sustainable freshwater ecosystem management must be set in place at global, regional, national, sector and local levels; and significant progress in overcoming the direct and underlying economic causes of freshwater ecosystem degradation and loss must be made across all countries, in all sectors and for all socio-economic groups.

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Box 4.5

Norwegian investors to base investment decisions on water use intensity of companies.

Shareholders are typically interested in looking at companies that are better equipped than their competitors to succeed in a complex future. In Norway, two investment firms believe that companies that care for the environment and can handle social challenges will outperform those that don't. In 1996, these companies launched the Storeband Scudder Environmental Value Fund that focuses on investment in companies with high environmental performance scores. The Fund uses eight indicators of sustainability to guide investments, including the water-use intensity of a company. By achieving a more than 53% net return over the 30-month period since its launch, the Fund has demonstrated that investors can achieve a good return on investment while providing incentives to companies to improve their water-use intensity and become more socially and environmentally responsible.

Source: Williams, 1999

Investments made within and outside the water sector should incorporate the full economic, ecological, cultural and intrinsic values of ecosystems' goods and services in decision-making. Adjustments to the current approach for cost-benefit analysis need to be made to include the cost of losing some of these values as a result of development activities. Governments should analyse and remove perverse incentives that induce water resources degradation, including subsidies to crops with high water consumption, and low water tariffs for large quantity users.

Investments can also be an incentive for enterprises to change their behaviour. Stakeholder or consumer pressure on companies to reduce their water use can be an effective tool. These can often be linked to codes of conduct to which 'peer' companies within similar industrial or commodity sectors want to sign up. Lead companies often benefit from enhancement of public image or from first mover advantages. 'Seen to be green' is important in markets where a business has a high profile with the 'purchasing public' such as, for example, the water consumer (see Box 4.5).

Innovative financing of sustainable catchment use and conservation

Financing of catchment conservation by NGOs, private companies and governments is a key element for change. Financial resources can be derived from proper costing of the goods and services provided by natural ecosystems (e.g. forests in upper catchments). Investments in conservation are often wiser than 'end of pipe' solutions such as river clean-ups. Innovative financing can also include the establishment of 'Catchment Trust Funds.' Voluntary contributions and service payments to a Trust are invested in conservation measures that improve catchment and water conditions from which Trust Fund contributors might directly profit.

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In the United States, for example, the Oregon Water Trust was established in 1993 to acquire water rights for maintaining instream flows to enhance the recreational values and ecological health of watercourses. By 1998 it had protected flow in 450 miles of river throughout the state of Oregon, on the basis of deals with over 50 water rights holders. It has acquired US$ 654,000 of water rights through donations and acquisitions. Private foundations provide 90 per cent of its budget, while private groups and public agencies provide in-kind support to the Trust. The Trust sometimes reimburses private landowners for loss of income; for example, when leaving water instream and not using it for irrigation. The Trust is helping to transform attitudes about water and people's acceptance of water markets in general. It provides an example of an alternative way of bringing together agricultural and fisheries interests, landowners and environmentalists, to develop constructive ways for sustainable natural resource management.

Trust Funds should only be set up where effective legal and institutional frameworks are in place. Financing of Trusts or direct conservation investments can, in some cases, be based on 'Debts for Nature/ Development Swaps.' These allow a developing country to invest in conservation and development for a reduction in part of its foreign debt. In general, existing aid mechanisms need to be strengthened and applied more to finance pilot projects in participatory ecosystem-based catchment management that can be replicated elsewhere.

In 2025,

ecosystems' full values are recognised...

GOAL	The economic, ecological, cultural and intrinsic values of ecosystems are fully incorporated in decision-making and management of water resources, using incentive measures and innovative financial and legal mechanisms.
TARGET	New incentives or economic and legal mechanisms developed and implemented for nature and water resources conservation are applied in the vast majority of catchments.

ACTIONS

- Resource managers, NGOs, and consultant agencies to further develop and implement economic valuation in planning/design and monitoring/evaluation of water resources management projects and activities to enable balanced decision-making on multiple resource use, development and conservation;

- NGOs and local governments to establish payment and subsidies to strengthen existing, or establish new, responsible, transparent and accountable local institutions that provide improved water delivery, drainage and sanitation services;

- Governments to remove perverse subsidies that promote inefficient use of water or freshwater ecosystem destruction, and to establish subsidies that promote conservation of critical habitats and stimulate the use of intermediate technologies for water saving and pollution reduction in agriculture, industry, and at the household level;

- NGOs, private companies and governments to carry out 'debt for nature & development swaps' and direct financial resources to develop catchment trust funds that finance the implementation and maintenance of rehabilitation and conservation measures within specific catchment areas.

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4.3 People's empowerment for responsible water use and conservation

Participation of local groups is essential for establishing grassroots sustainable water management and conservation. Faced with resource shortages, people will first address their own needs: their fields, their farms, their livelihoods, and their villages. Only when these are adequately addressed are they likely to consider catchment issues. Ecosystem-based catchment management can therefore only be implemented successfully when it takes a similar path; a path that is based on people's well-informed decision-making, and adaptation to changing conditions. This is a process that enables humans to improve their standards of living and lead their lives in dignity and fulfilment, while learning to conserve their resource base and contribute in a meaningful way to solidarity within their society.

Establishing public participation

Devolution of power to local levels, and people's participation in water management decision-making, requires individuals to take up new responsibilities and become actively involved. Water-related problems have taken a long time to reach this critical stage; persistence, tempered with patience, is needed to find solutions. Energy and capacities exist at local levels that can be complemented, where appropriate, with technical expertise provided by NGOs, CBOs, research institutes or governments.

Equitable sharing of water resources

Achieving sustainable use of freshwater ecosystem resources will require equity in both decision-making and sharing of resources. To achieve equity within and between households, communities and nations will require NGOs, governments and private companies to maintain and sometimes create efficient, representative and sustainable institutions for catchment management. These institutions will have to provide alternatives for disenfranchised individuals and communities whose security is based on access to freshwater ecosystems and whose control over these resources has eroded (see Box 4.6). Reducing the vulnerability and uncertainty of livelihoods is essential, and can be supported by providing greater choices in management and income generation to local communities. Empowered local communities should be given a fair share of the resources or the revenues from these to allow them to manage their livelihoods in a fair, sustainable and effective manner (see Box 4.7).

Gender equity in relation to water resources use and management is crucial for resolving potential water conflicts, enhancing social security, and improving strategies for water conservation, pollution control and demand management. The identification of obstacles to the broad and fair participation of women in water resources management is therefore fundamental for the implementation of sustainable and equitable resource use practices. While it is axiomatic that both women and men should have an equal right to access, around the world, women and men play different roles with regard to maintenance and use of water resources. Women often have unequal access to, control over and benefits from water resources. To establish a gender balance in water management will require substantial but subtle changes to be made to the ways that both men and women collectively manage freshwater and related ecosystems. Everywhere – in the north and the south, in the east and the west – traditional and innovative mechanisms will need to be applied by NGOs, governments and private companies to specifically empower not only women, but also our youth and the elderly, within the water use decision-making and management process.

Box 4.6

Self-help Credit Management Groups for implementing sustainable catchment management (Gulbarga, India).

In 1988, a joint project between the state government and the Swiss Development Cooperation was initiated to give farmers increasing control over catchment resources. The project focused on developing farmers' skills, building confidence and developing organisational expertise to control resource use and increase productivity in a sustainable way. Central to the project was the development of Self-help Credit Management Groups (SHG), which are socially functional groups in micro-catchments that require no outside intervention to remain viable. Such groups usually have fewer than 20 members, who share a common interest and are largely homogeneous in terms of caste, class and livelihood. The SHGs developed skills to manage credit and institutionalise and administer cooperation. The project has shown that SHGs are very effective at practical resource management, but need to be complemented by Catchment Management Committees to incorporate the interests of landless and marginal farmers.

Source: Fernandez, 1998

Defining rights and entitlements of local groups

Inequitable distribution of, and access to, water resources prevents millions of people from attaining a better life. Certainly economic growth is an important factor for change, but social justice cannot be achieved solely through economic means. It is imperative that governments clearly define water and land tenure, access and user rights. All people need to enjoy access to water resources and sanitation to attain a decent standard of living. Women, in particular, often rely directly on the natural environment, and are among the most affected by its pollution and decimation – yet all too often they are not involved in the major decision-making that determines its management and use. Likewise, everybody must accept and share the corresponding responsibilities, such as complying with conservation and protection regulations in order to safeguard the resource base.

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Box 4.7

Local empowerment for sustainable use of resources: The CAMPFIRE experience (Zimbabwe).

Sustainable rural development requires strategies that enable people to improve their quality of life while maintaining their natural resource base. The Communal Areas Management Programme for Indigenous Resources (CAMPFIRE) in Zimbabwe has developed an entrepreneurial approach to development based on sustainable wildlife management. By 1997, 30 districts and over 6 million people were involved, and household income had increased up to 25% due to the improved marketing of wildlife products. The sustainable use of wildlife products gives communities an alternative to destructive land use practices. The CAMPFIRE programme shows that wildlife protection and development can go together and provide benefits for both local people and the environment.

Source: The Zambezi-IMERCSA Newsletter, 1998

Local groups share in ownership of water infrastructure and land

Land and water resources within catchments are owned by a wide variety of people and institutions. Most of the world's farmers are small landowners, although in some countries large farms are occasionally farmed by tenants. Water resources ownership is sometimes linked to land ownership, but most water resources are state owned. A proper definition of ownership is essential for sustainable management, and a fundamental prerequisite if local people are to invest in improvements to the land, spring, well, river or lake that they use.

Because government agencies or private developers own most infrastructure within catchments, revenue from such infrastructure (e.g. dams and reservoir facilities) seldom benefits those who are most affected by its development and operations. If the governments and developers were to enable local groups to become shareholders in large infrastructure, the people would not only benefit from the revenue but, as users, they would also be inclined to invest in conservation measures such as, for example, upper catchment afforestation or allowing instream flow for fish production.

Training leaders and community groups

Strong leadership at local levels is essential for bringing about change. Leadership can be individual, as in the case of a community leader who provides guidance and encouragement, or it can be collective, as in the case where a strong group spirit makes a collective change towards sustainable water resource use. NGOs and governments should develop new training programmes in pilot catchment areas for individual and group leaders, in order to initiate fair and equitable dialogue with state and private organisations concerning sustainable resource use and conservation.

In 2025, people are empowered and equitable access to water is ensured...

GOAL	Empowered local groups develop responsible water-use practices and attain equitable access to water resources for all, while respecting ecosystems as equal 'partners.'
TARGET	In all infrastructure projects and the vast majority of river or drainage basins, local groups take part in power-neutral negotiations of water and land resource allocations.

ACTIONS

- Establish effective public participation through involvement of NGOs and CBOs in decision-making and management of catchments;
- NGOs, governments and private companies to establish a social and gender balance in all water-related decision-making structures at all levels, ranging from the local community to international institutions;
- Governments to develop and enforce compliance with effective legal and policy frameworks that define the property and access rights to water resources, including the primary right of ecosystems for water;
- Developers and governments to share ownership of new and existing infrastructure, such as dams, gates and dikes, with local groups, to allow revenues to directly benefit these groups and have them directly involved in the operational management;
- NGOs and governments to develop training for local leaders and competent groups to allow them to communicate with institutions in a fair and equitable manner to ensure full participation in resource negotiations.

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4.4 Political will and good governance for collaboration and consensus

Participation not only means local involvement in decision-making and management. Increasingly, a host of local, provincial/state and national groups and institutions, ranging from governmental to non-governmental, and technical to political, are involved in the planning and management of natural resources. Power-neutral negotiations are fundamental to participatory ecosystem-based catchment management. This requires participants to adopt and be committed to a transparent, truthful and faithful planning and negotiation process. To establish this process there are at least two prerequisites: firstly, an effective legal system that protects citizens against injustice should be in place and, secondly, an appropriate institutional set-up that provides equal opportunities for all parties to be informed and participate in the planning and negotiation process. In many cases, local groups will only be able to join the planning or negotiations when they are able to raise sufficient public attention and action or build a legal case that allows them to participate. Political freedom and guaranteed human rights are essential for achieving this.

Commitment to accept the responsibility to care for nature

Despite decades of discussions and efforts to improve water management around the world, little progress has been made due to the lack of a common will and commitment to make sustainable water management happen. At the political level, this has been caused partly by the fact that many direct effects of water resources degradation or depletion are beyond the common political time horizon of 3 to 5 years. Only in cases of catastrophic events or acute water scarcity has political will and awareness been raised. A critical step is thus the creation of political will and commitment among political parties, at local, national and international levels, to seriously invest human and financial capital in the protection of freshwater and related ecosystems.

Public awareness, private sector responsibility and a general commitment among local groups to protect water resources are fundamental to establishing change. Often underestimated but potentially influential is the role of religious groups (see Box 4.8). These can provide leadership, and raise the awareness of communities and individuals of the need to protect our environment and take personal responsibility for caring for it. Community-based groups, such as service and user groups, labour unions, and women's and youth organisations, also have a key role to play in stimulating changes in human behaviour to spread around the world.

Box 4.8

Catholic Church calls Columbia River 'sacred' and urges protection.

Catholic bishops in north-western United States issued a 65-page document in May 1999 urging people to view the Columbia River as a 'sacred source of life and a symbol of our connection to the divine.' The river and its dams currently form a focal point for dam decommissioning. The published document precedes a pastoral letter to be published in 2000, in which responsibilities of citizens with respect to the management of the river are outlined. These range from saving the salmon to honouring treaties with Native Americans. As Bishop William Skylstad says, "The symbolism of water is life giving, cleansing and nourishing." This initiative exemplifies the actions that religious groups can take to preserve water resources.

Source: IRN, 1998

Compliance with existing laws, regulations and ethical codes

Community-level and broader institutional changes towards freshwater ecosystem conservation will not come without a real effort. Government leadership and political will is required to make this change happen. Civil society groups, including political parties and religious organisations, need to become involved in the water debate and pressure governments and corporate citizens at national and local levels to establish compliance. Likewise, agricultural enterprises and industries must take responsibility for compliance with existing regulations and for making freshwater ecosystem conservation a high priority.

Evidence shows that industry can, in fact, expand production and remain profitable while reducing freshwater consumption, providing it also maintains basic housekeeping, management attention, technological innovation and commitment from all employees. On the Danish island of Als, for example, in the Baltic Sea, one industry voluntarily reduced its water consumption to help restore local groundwater resources. Danfoss discovered in 1984 that their facility was responsible for the extreme lowering of the water table beneath the island. The danger of saltwater intrusion caused the local authorities, in 1989, to reduce the permissible water extraction for the facility to 2 million cubic metres per year. Danfoss had already started to detect and repair the major leaks in its water supply and sanitation system, which resulted in an 80 per cent reduction in water use, by 1998 (compared to the 1983 levels) (Danfoss 1998).

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Policies and laws at international, national, subnational and regional levels should be further developed and harmonised by governments, and possibly United Nations agencies, to enable nature conservation and more equitable water and land resource use. The entire legal framework should facilitate accountability for environmental care for both the corporate and public sectors, as well as individuals. New laws should be based on principles derived from a wide consultative process (see Box 4.9). Besides legal frameworks, private companies, governments and NGOs will need to develop 'codes of conduct' that allow private and public groups of water users to develop environmental and water care on a voluntary basis, reducing water use and effluent emissions, and banning freshwater and coastal ecosystem destruction.

Basin agreements implementation and institutional reform

Responsibility for the development and management of water resources needs to be delegated to catchment and drainage basin levels in a way that enables affected parties to be empowered and participate. In many cases, substantial institutional reforms will be required to develop a service-oriented approach that is receptive to local needs and perceives effective local participation as a valuable asset in the planning and management of water resources. To bring about this change, considerable political will and commitment needs to be developed; a commitment to reform current sector-oriented policies and to initiate and maintain good governance aimed at establishing participatory ecosystem-based catchment management. Establishing new or strengthening existing independent arrangements is therefore required for river and drainage basins at national and international levels.

To turn these ideas into reality, sources of funding will also have to be made available. Governments, for example, could potentially finance large infrastructure development, and provide emergency payments and green innovation subsidies, while private investors could fund the operation, maintenance and rehabilitation of large infrastructure projects. Community associations could support local activities, particularly their maintenance. Taxes could be collected from industrial water users and large-scale farmers, with small farmers contributing proportionately smaller amounts, and water pricing could be set for urban dwellers, with subsidisation for the poor. On an international scale, ecosystem rehabilitation programmes could be funded by international donor agencies.

Networks of communities, research organisations, provincial/state and national authorities and organisations, river basin committees/authorities and NGOs will need to establish and strengthen cooperation, develop linkages with all stakeholder groups, and set up and maintain structures that ensure transparency, independence, accountability, democracy and use of 'best knowledge.' This will often require major reforms to allow people and institutions to change dysfunctional bureaucracies into service-oriented bodies that reach out to the public. Public or private organisations need to create partnerships that build on local initiatives and match these with appropriate know-how, technologies, new policies, laws and financial means.

In Coos Bay, Oregon, in the northwestern United States, successful partnerships managed catchments and reduced freshwater pollution to restore and maintain the coastal fisheries. Haynes Inlet has been known as a desirable shellfish production area because it provides rich mudflats and clam waters during storms. Shellfish production was, however, prohibited because of elevated faecal coliform counts. Downstream oyster growers began asking owners upstream in the catchment for help to reduce pollution levels. Some of them responded positively and started to restrict cattle access, replant riparian areas and install nose-pumps for cattle to drink from. In addition, a new law was passed that safeguards landowners from losing their right to river access if streambank stock exclusion measures are carried out. The initiative showed that strong councils to represent landowners, technical guidance by coordinating agencies, and partnerships between upstream and downstream users, landowners, enterprises and state agencies are essential for a successful reduction of contamination levels, protection of habitat and conservation of biodiversity (Environmental Protection Agency 1997).

Box 4.9 South Africa

Principles for a new water law in South Africa to manage resources sustainably and protect the environment.

The new water law in South Africa is based on 28 principles. First published in 1996, these have undergone a number of revisions to incorporate the comments received through public consultation before being approved by the South African Cabinet. The principles indicate that water, anywhere in the water cycle, is a common resource. No ownership is granted; only a right is given for environmental and basic human needs or an authorisation for its use over a fixed term. The principles recognise the unity of the water cycle together with the variable, uneven and unpredictable nature of water distribution. The objective of water management is to manage the quantity, quality and reliability of the nation's water resources to achieve optimum, long-term, environmentally sustainable social and economic benefits for society from their use. Basic human needs and environmental requirements are identified as 'The Reserve' and have priority of use by right. Water use for all other purposes is subject to authorisation. The new principles and law give not only guidance for South Africa, but provide a legal innovation for the world to consider for national legislative development.

Source: Asmal, 1998

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In 2025,

political will and good governance reign...

GOAL	Political will and good governance are established to avoid and mitigate conflicts, and to build collaboration and consensus among all stakeholders on the basis of informed participation.
TARGET	In the majority of all catchments, stakeholders' full participation and transparency in decision-making is established.

ACTIONS

- Political parties, religious organisations and local groups to demonstrate commitment to conserve rivers, lakes, groundwater reserves, wetlands and coastal areas, through involvement in resolving water use conflicts and terminating destructive and polluting practices;
- Governments to stimulate and enforce compliance with environmental regulations; for example, during development and operation of water-related infrastructure, during operation of industrial activities and while farming;
- UN agencies, governments and NGOs to develop and implement effective and efficient mechanisms to negotiate transboundary problems and resolve or mitigate conflicts revolving around major international river basins;
- River basin organisations, governments, civil society groups, donors and investment agencies to facilitate and support the implementation of river/drainage basin or catchment agreements and policies, facilitated by appropriate staffing provided by governments;
- Private companies, governments and NGOs to develop and comply with voluntary 'codes of conducts' for various groups of water users to reduce water use and effluent emissions, and to ban freshwater and coastal ecosystem destruction;
- NGOs, research organisations, governments and private enterprises to design and implement strategies to share information with civil society groups (e.g. communities, women's organisations, youth groups, professional organisations) to enable informed participation in decision-making and ensure transparency.

4.5 Promote behavioural change by increasing awareness and capacity

Awareness of ecosystem benefits and the consequences of human-induced changes is essential for making a sustainable water world a reality. In order to want to act for environmental conservation, people must attain a general level of understanding of, and caring for, ecosystem functions and benefits (e.g. the water cycle, the role of catchment protection for drinking water and aquatic life, the biodiversity of freshwater systems, and the relationship between land-based activities and marine and coastal zones). Education, training and capacity building will put people in a better position to make informed choices and act to conserve the resources within their catchment area.

Awareness alone, however, is not enough to establish sustainable practices. People must also be willing and able to pay and be prepared to act in an environmentally responsible way. All too often, discrepancy exists between awareness of water resource base deterioration and consequent changes in behaviour. Only when direct benefits can be clearly demonstrated is awareness likely to lead to a change in behaviour. The major challenge lies in bringing about the changes that do not provide direct immediate local benefits, but are nonetheless required to provide services downstream or in the future. Often catalysing events are needed to make this happen (see Box 4.10).

Communication materials to reach out

To bring about change, effective communication is needed between local groups, scientists, water managers and decision-makers, as well as the translation of their ideas into action. In order for this to happen, communication materials must be developed, both by and for local groups, to better understand the nature of the issues at hand. It is fundamental that youth organisations, women's groups and local resource managers develop and use do-it-yourself materials to promote the conservation of freshwater and related ecosystems.

The achievement of this Vision necessitates the establishment of conditions that enable humankind to live up to its moral and ethical obligation to protect biodiversity.

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A major shift also needs to take place in the outreach from research institutes and universities to civil society groups, communicating research findings in appropriate formats. Furthermore, two-way communication needs to be established between communities, scientists and governments to stimulate the exchange of ideas and develop extremely innovative research work on appropriate natural resources management approaches and technologies.

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Box 4.10

Catalysing events needed for change: Yangtze flooding initiates discussions in P.R. China.

The 1998 flooding on the Yangtze River (P.R. China) has induced much discussion and some political action at the highest level. In late 1998, China's State Council banned logging in Sichuan province in response to the flooding of 64 million ha of land that caused over 3000 people to die. Further land reclamation in the Yangtze floodplain was prohibited and US$ 2 billion was allocated for reforestation projects in the upper reaches. Some Chinese officials, however, criticised the bans, citing them as often being poorly thought-out, badly implemented and rarely working; they pointed to the need for complementary action at the county and village levels. Although a state ban might not be the most effective measure, the Yangtze flooding did trigger important discussions on the management of China's major river basins. Awareness about the need for catchment management is the first step towards sustainable use.

Source: Pomfret, 1998

Up-to-date knowledge and information provided by technical experts needs to be twinned with local/ traditional knowledge, and translated into understandable messages and modules. Substantial resources are needed to develop and disseminate these materials and maintain education networks.

Formal education and training to enable people to act

Primary and secondary education are the cornerstones of modern societies. The integration of environmental learning into school curricula – for example, information about the goods and services provided by ecosystems, the richness of species in rivers, lakes and coastal areas, and the cause-and-effect relationship between human actions and environmental conditions – forms the basis for environmental awareness and environmentally-responsible behaviour, now and in the future.

Schoolchildren can initiate catalysing events. Several years ago, for example, when students in Victoria, Australia, started to talk about salinity problems at home and showed maps with the results of school-monitoring activities, the issue was brought out in the open. Prior to this, farmers tried to deny the existence of salinity for fear of losing land value. The students provided a lever to bring the community together to address the problem (Mobbs 1995).

Universities and technical institutes should also further develop curricula for freshwater and related ecosystem management. These should include interdisciplinary programmes for engineers, socio-economists and social scientists, managers and environmental scientists to ensure that a holistic view of ecosystem management is shared by all relevant disciplines. Almost everywhere, scientists need special training to improve their communication with resource managers and the public, and to become more responsive to local needs.

Likewise, NGOs should develop training programmes for both community involvement and national capacity in environmental management. Particularly important is the education of youth, women, technicians and decision-makers on the economic, ecological, cultural and intrinsic values of freshwater and related ecosystems. Training is needed to develop national capacities to deal with ecosystem-based catchment management.

In developing countries, increased capacities would enable empowered communities to participate more widely in negotiations of water resources allocations and management. Current dominance of foreign technical assistance should be transformed into assistance for capacity building for academics and engineers.

Exchange of experience for solidarity and capacity building

Changing current practices on the ground requires farmer-to-farmer, woman-to-woman, and teacher-to-teacher exchanges intended to share hands-on practices and lessons learned, and develop self-help initiatives. These exchanges could take place on many scales, reaching from local to national and even international, where exchanges on specific topics are likely to be beneficial. It is essential that NGOs, governments and United Nations agencies actively facilitate the establishment of partnerships between local groups, scientists, engineers, decision-makers and managers, which should then form the basis for ecosystem-based catchment management (see Box 4.11).

In West Africa, for example, a network of managers, policy makers and scientists helped improve floodplain management. In 1992, IUCN - The World Conservation Union initiated the development of the Sahel Wetlands Expert Group (SAWEG), whose aim is to build members' capacity to manage West African floodplain resources sustainably. SAWEG brings together approximately 100 specialists in water engineering, health, ecology, hydrology and law, based at universities, research centres, government institutions and river basin authorities in Burkina Faso, Cameroon, Chad, Gambia, Mali, Mauritania, Nigeria, Niger and Senegal. A series of meetings was organised to discuss topics such as water-quality modelling, participatory rural appraisal, training needs, legislation development and local participation in management. The outputs are pulled together in a book *The West Africa Floodplain Manual* (IUCN 2000). The experience with SAWEG has shown that cross-sectoral collaboration and exchange can

Box 4.11 USA

Environmental networks build on youth to implement successful conservation.

Environmental education networks are a new way of exchanging innovative approaches for reaching and working together in environmental conservation. An example of such a network is Earth Force (USA). This youth-driven organisation, created in 1994, is governed by a national Youth Advisory Board (YAB) made up of 15 members, ages 10 to 17. It builds on young people's overwhelming desires to act on behalf of the environment and to help their communities through voluntary service. Surveys show that, despite declining interest in political affairs, young people are increasingly involved in their communities. Through Earth Force, youth discover and implement lasting solutions to environmental issues in their community. In the process, they develop lifelong habits of active citizenship and environmental stewardship. Educators turn to Earth Force for innovative tools to engage young people in community problem solving.

Source: Earth Force website

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by 2025,

increased awareness and capacity provide the impetus for sustainable behaviour...

GOAL	Awareness is raised about the need for ecosystem protection and sustainable water use, and human capacity is strengthened to enable behaviour changes that respect and are compatible with nature.
TARGET	The majority of awareness-raising campaigns carried out at local, national and regional levels, based on information from local groups, universities and research institutes, lead to tangible conservation interventions and results.

ACTIONS

- Youth organisations, women's groups and professional organisations to develop and use 'do-it-yourself' communication materials to promote efforts from specific target groups to conserve wetlands, rivers, groundwater resources, lakes and coastal areas;
- NGOs and technical institutions to set up training courses and formal education programmes to develop national and local capacities to implement participatory ecosystem-based catchment management;
- NGOs, governments and UN agencies to develop local, national and regional interdisciplinary exchange programmes aimed at sharing hands-on practices and lessons learned, and developing self-help initiatives for freshwater ecosystem conservation and sustainable management of river/drainage basins.

best be facilitated through an informal network that focuses on capacity building of its members to develop alternative and sustainable development options (Acreman 1996).

Strengthening human resources and capacities in both freshwater ecosystem assessment and management and implementation of local conservation measures will require training schools and on-the-job training facilities to be established. Donor funds will be required in some parts of the world to kick-start these activities.

4.6 Develop, maintain and exchange knowledge and information

Existing information on and knowledge about freshwater ecosystems and their functions needs to be further developed, especially in relationship to their sustainable use. Essential questions relate to best practices with respect to participatory ecosystem-based catchment management, water requirements of ecosystems, and benchmarks for freshwater ecosystems and species against which their future state can be evaluated. Scientific knowledge is, however, not the only knowledge that holds answers. Local knowledge and expertise is essential for the understanding needed to develop and implement sustainable management practices in catchments.

Importing ready-made solutions from elsewhere that ignore local knowledge, customs, rights and entitlements will most often result in a failure in the long run, and is socially unacceptable. This practice jeopardises the empowerment and engagement of local groups in sustainable water resources management. In some cases, local knowledge may hold the key to sustainable practices that protect catchments (see Box 4.12). In other cases, a part of the solution comes from adjusting an existing technological approach, such as redesigning a dam to allow environmental flows (see Box 4.13). Only a combination of traditional and new knowledge will provide the base of understanding needed for sustainable water management. The empowerment of a responsible and capable scientific community in the South is required, and should result in the development of an effective research capacity within a single decade in many countries.

Participatory catchment management and conservation – how to do it best?

The approach presented here is relatively new and only a very limited set of experiences have yet emerged. Essential to the approach is the establishment of monitoring and evaluation systems that enable us to track the progress and effectiveness of jointly-defined interventions. A key element is improving our understanding of the relationship within the catchment between poverty alleviation and nature conservation.

Indicators, both quantitative and qualitative, should be defined and used. These should not only entail purely scientifically-measurable variables, but also include the viewpoints of individuals and local groups; for example, their satisfaction with their current livelihoods, the degree of adaptation to introduced recommendations, and the woman-to-woman, fisher-to-fisher, farmer-to-farmer spread of new or improved methods. To gather that information and make it widely available will require a joint effort of many networks, to be set up by governments, NGOs, United Nations agencies, and local groups.

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Box 4.12 Honduras

Traditional farming techniques in Honduras conserve soil and water resources during Hurricane Mitch.

Although Hurricane Mitch devastated large areas in Honduras and Nicaragua in 1998, the remote village of Guarita (Honduras) was only slightly affected in contrast to many of the surrounding areas. The traditional Quezungal farming method practiced by the local villagers had protected the upper-catchment and reduced the loss of crops to only 10 per cent. The method involves planting crops under trees whose roots anchor the soil, pruning vegetation to provide nutrients to the soil and conserve soil water, and terracing to reduce soil erosion. Methods previously taught at the agricultural colleges and practiced in surrounding areas caused much damage, as they are suited for cultivation of plains but are unsuited for farmland located on hillsides. The traditional Quezungal method avoids widespread slash-and-burn and improves soil fertility. It is now being actively promoted by the Honduran government in collaboration with the UN Food and Agriculture Organisation (FAO). This example indicates that traditional techniques can be superior to cultivation techniques imported from other agroecosystems. Sustainable management of soil and water resources requires the adaptation of techniques to local conditions and the incorporation of traditional knowledge in the development of improved water management.

Source: Gunson, 1998

Box 4.13 Lesotho

Technical adjustments to dam design allow for environmental flows (Lesotho).

The Lesotho Highlands Water Project (LHWP) is an interbasin transfer project that would export water from the Senqu/Orange River in Lesotho to South Africa. As part of the project, an Environmental Flow Assessment is carried out, financed by the World Bank. The study focuses on understanding the complete river ecosystem and on developing a series of flow scenarios. Each scenario describes a possible future flow regime in the river system (resulting from dam releases and catchment runoff) and the resulting conditions of the river. Preliminary findings have already influenced the design of the Mohale Dam in the form of a multiple-outlet structure, including a higher capacity, lower-level outlet. These structures would allow releases of varying quantity and quality, including occasional flood flows, to meet the requirements of downstream ecosystems. Although there is continuing controversy over the entire LHWP, and especially the risks to biodiversity occasioned by large-scale interbasin transfers, the Environmental Flow Assessment project, a landmark for the World Bank, exemplifies how a methodology can be adopted that integrates biophysical, social and economic considerations in water resources development.

Source: World Bank, 1999

Ecosystem water requirements – setting environmental flows

Ecosystems need water to preserve species and maintain essential natural processes. Increasingly, scientists and water resource managers are developing methods to set standards for leaving water in rivers, lakes and aquifers for maintaining these systems. However, a considerable scientific effort is needed to gather the required basic information and improve our understanding of flow regime, water quantity and the quality requirements of these systems. Since disputes over the allocation of water among multiple users most often result in loss of the residential flows needed by ecosystems, methods must be devised that are not only scientifically sound but that will stand up in a court of law and in the court of public opinion. A network of scientists and practitioners, comprising developers, technical institutes, NGOs and United Nations agencies, should be established to further gather required information, and to produce synthesised knowledge to define appropriate methods and models for instream flow requirements for specified conditions, ecosystems or species.

Biodiversity and ecosystem monitoring and benchmarking

Current information of freshwater ecosystems and biodiversity is incomplete and lacks a global coverage. These information and knowledge gaps prohibit, in many cases, raising awareness about the situation and promoting adequate actions to be taken. Priorities will need to be defined for these actions, partly on the basis of available scientific information on most rich or vulnerable ecosystems and species. Research institutes and NGOs will need to establish benchmarks for environmental indicators in order to evaluate the effectiveness of conservation interventions and the effects of other management activities. They will then need to use these indicators to conduct periodic inventories of the status of freshwater ecosystems, which can subsequently be linked to national monitoring strategies as defined under the Convention on Biological Diversity and the Convention on Wetlands (Ramsar 1971) (see Annex 2). National and global dissemination of information and knowledge is also needed, both by using new technologies and by greatly expanded collaborative networks of NGOs, CBOs, educational groups and governments.

Hydrometeorological networks maintenance and use

The collection, storage and use of hydrometeorological data is an essential element of catchment management. They provide the baseline against which project interventions can be evaluated. Improvements in environmental conditions at local levels will not, however, necessarily be immediately reflected in the baseline conditions of the basin. Variations in rainfall distribution over the catchment and the timing of events can create considerable interannual variability. A long time-series is therefore needed as a basis for adequate planning and management.

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In many countries, the existing hydrometeorological networks are badly maintained and show increasingly severe data gaps that render them almost useless for many applications. Government must commit resources to existing networks, which they should maintain with assistance from UN agencies, in order to build the knowledge and information base that is needed and to develop and manage water resources sustainably.

Development and application of appropriate technologies

New, affordable, environmentally-sound, appropriate technologies for water management should be developed by companies and NGOs, based on local indigenous knowledge and scientific expertise; for example, appropriate new techniques to reduce water demand and treat wastewater. Many existing techniques require substantial maintenance that often is not carried out in a large number of countries. Companies and NGOs, together with communities, resource-user groups and research institutes, should give priority to investing in the research and development of these techniques, and to applying and testing them. Likewise, these groups should make considerable progress in the application of artificial wetland technologies for effluent treatment, especially for tropical conditions. Further development and testing of appropriate dry-sanitation technologies is also needed.

integrated knowledge is applied to ecosystem management...

GOAL	Scientific and indigenous information, knowledge, know-how and technologies are developed and used to improve the management of freshwater and related ecosystems.
TARGET	In most countries, integrated networks produce synthesised knowledge and expertise, directly contributing to efforts to conserve freshwater ecosystems and biodiversity.

ACTIONS

- NGOs, UN and national agencies to set up and manage networks of field managers, scientists and decision-makers to compile and develop experiences on management and conservation of freshwater ecosystems within river or drainage basins;
- NGOs, UN agencies, developers and technical institutions to establish global/regional network(s) to review, develop, test and apply approaches to determine and allocate ecosystem water requirements;
- Research institutes and NGOs to develop freshwater species and ecosystem inventories, and set ecosystem and species benchmarks to evaluate change and define intervention priorities on the basis of rational and defensible limits to ecosystem and species loss;
- Governments to maintain and finance, and UN agencies to assist in maintaining, hydrometeorological networks that provide information in appropriate formats to water resources planners, managers and the general public;
- Companies and NGOs to develop and use soft-engineering methods to manage water resources and rehabilitate degraded freshwater ecosystems including, for example, artificial wetlands for effluent and runoff treatment, and floodplain restoration for flood attenuation;
- Communities, resource-user groups and research institutes to develop, test and improve small-scale appropriate methods to sustainably manage, conserve and rehabilitate rivers, wetlands, groundwater, lakes and coastal areas.

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Acronyms, Glossary, References and Annexes

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Acronyms

CAMPFIRE	Communal Areas Management Programme for Indigenous Resources (Zimbabwe)
CBD	Convention on Biological Diversity (UN)
CBO	Community-based Organization
EIA	Environmental Impact Assessment
EMAAP-Q	Quito Municipal Sewage and Water Agency (Ecuador)
ENGO	Environmental Non-governmental Organisation
EPA	Environmental Protection Agency (USA)
FAO	Food and Agriculture Organisation (UN)
HCCPR	Hadley Centre for Climate Predictions and Research (U.K.)
INEFAN	Forest and Natural Areas Institute (Ecuador)
LHWP	Lesotho Highlands Water Project
MDB	Murray Darling Basin (Australia)
NGO	Non-governmental Organisation
OECD	Organisation for Economic Cooperation and Development
POP	Persistent Organic Pollutant
SAWEG	Sahel Wetlands Expert Group
SDC	Swiss Development Cooperation
SHG	Self-help Credit Management Groups
TNC	The Nature Conservancy (USA)
UNEP	United Nations Environment Programme
WB	World Bank
WCMC	World Conservation Monitoring Centre (U.K.)
WWF	World Wide Fund for Nature
WRI	World Resources Institute (USA)
WTO	World Trade Organisation
YAB	Youth Advisory Board

Glossary

Accessibility: the proportion of the total potential goods and services that is available for use.

Aquifer: underground rock or sediment layer containing water.

Biological diversity or biodiversity: the variety of life in all its forms, levels and combinations, including ecosystem diversity, species diversity and genetic diversity (IUCN, UNEP and WWF 1991).

Carrying capacity: capacity of an ecosystem to support healthy organisms while maintaining its productivity, adaptability, and capability for renewal.

Catchment: unit of land from which water flows downhill to a specified point on a watercourse, as determined by topographical features, and bordered by the divide (e.g. watershed, river basin, drainage basin).

Civil society: sphere of autonomous institutions, protected by the rule of law, in which men and women may conduct their business freely and independently of the state.

Community: the social groupings that the individual household lives within.

Connectivity: measure of the degree of cohesiveness of a system; systems with strong interaction have a high connectivity, as have systems with a large number of the parts interlinked.

(Nature) conservation: protection against irreversible destruction and other undesirable changes, including the management of human use of organisms or ecosystems to ensure such use is sustainable.

Coping strategies: sets of activities that people adopt in the face of threats such as resource degradation, market collapse, conflict or other forces that affect the viability of their livelihoods.

Ecological evaluation: determining the value of something; for example, the value of ecosystem functions provided by natural ecosystems to human society.

Economic security: means of resolving conflicts between economic activities while providing for the maintenance of the natural services.

Ecosystem: any unit limited in space that is made up of a biotic community interacting with the physical environment so that a flow of energy leads to a clearly defined trophic structure (food chain) and material cycles within the system. Ecosystems may be small and simple, such as a small isolated pond, or large and complex, such as a specific tropical rain forest or a coral reef in tropical seas.

Ecosystem functions: capacity of natural processes and components to provide goods and services that could be used or are being used to improve the quality of human life.

Ecosystem integrity: continuity and completeness of a complex system, including its ability to perform all essential functions over its entire geographic range; the concept of integrity within a managed system implies the maintenance of key components and processes over time.

Ecosystem management or ecosystem approach: deliberate and conscious manipulation of ecosystem structure and/or function, or regulation of human uses of ecological systems, so as to retain defined and desired features and processes, and to meet human needs in an optimal and sustainable way.

Efficiency: making best use of the total package of resource potentials or endowments.

Entitlement: set of commodities that can be acquired by a person or group on the basis of rights, opportunities, ownership or social custom.

Environmental assessment: estimation of the magnitude or quality of the natural environment (air, water, soil) or investigation of the way in which one function or activity affects another function or activity.

Environmental security: a means of achieving long-term social, economic and ethical security through: i) sustainable utilisation of renewable resources and ecosystem functions; ii) protection from natural hazards; and iii) conservation of other species.

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Equitability: activities which enhance equity, giving priority to the poverty and gender dimensions of development and resources management in a sustainable way through meeting the needs of all stakeholders.

Equity: a way of resource distribution by which one user does not harm other users, now or in the future, and that is based on fulfilling the greatest need instead being driven by economic or other forms of power.

Flood recession agriculture: a form of usually small-scale or artisanal agriculture, practiced mostly in Africa and Asia, whereby the farmers retreat from the fields during the flood season but then take full advantage of the silt and nutrients left behind by the floods by planting crops in the floodplains. Little or no artificial fertilisation or irrigation is required.

Freshwater resources: fresh water, in all different parts of the hydrological cycle, all the living beings existing in these waters, and all the goods and services provided by them.

Good governance: a democratic way of governing a country or institution, taking into full account the needs and aspirations of all citizens and stakeholders.

Institutions: processes and structures that lead to regularised patterns of decision-making and behaviour.

Integrated Catchment Management (ICM): coordinated planning and management of the water resources of a river basin, considering its interaction with land, water and other environmental resources for their equitable, efficient and sustainable use at a range of scales from local to catchment level.

Intrinsic value: the worth of an attribute in and of itself, regardless of whether it serves as an instrument for satisfying individuals' needs and preferences.

Legitimate: open, fair and accepted by all concerned, requiring an institutional framework for decision-making that is representative of all interests.

Livelihood: capabilities, assets (including both material and social resources) and activities required for a means of living; a livelihood is sustainable when it can cope with and recover from stresses and shocks, and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base.

Livelihoods assets: the means of production available to a given individual, household or group that can be used in their livelihood activities, including natural capital, social capital, human capital, physical capital and financial capital.

Overexploitation or overharvesting: the use or extraction of a resource to the point of depletion or extinction, or the decimation of a population to a level below the minimum needed for a sustainable yield.

Perverse subsidies: financial arrangements or mechanisms that act against the common good; for example, a subsidy to support water extraction for irrigation that ultimately leads to conflict with other valid requirements for water.

Precautionary Principle: the idea that, where serious uncertainties exist, potentially damaging resource exploitation should not take place until it can be demonstrated that the risks are within acceptable limits.

Protected area: an area dedicated primarily to protection and enjoyment of natural or cultural heritage, to maintenance of biodiversity, and/or to maintenance of life-support systems.

Rehabilitation: conversion of a degraded ecosystem to an alternative state or use, designed to meet a particular management objective, mostly related to biodiversity conservation.

Resilience: buffering capacity of a system to changing conditions.

Resource degradation: resource utilisation that diminishes the total actual or potential resource endowment, now or in the future.

Resource endowment: total existing and potential package of goods and services that can be extracted from a given resource base.

Restoration: conversion of an ecosystem to the condition it was in prior to anthropogenic disturbance.

Robustness: the property of remaining unchanged even under the influence of new forces, new data or new perspectives of observation.

Sanitation: the safe disposal or reuse of excreta and other effluents from urban, industrial and agricultural use.

Scarcity: for water resources, the limited availability of, or limited access to, the many different services water resources provide. Scarcity can mean that there is simply not enough water available (leading to questions about how to allocate what is available) but, for many, the issue is the quality of the water resources, the consequences of different, incompatible uses competing for the same resources, or the social, economic or institutional barriers which limit access to resources which are abundant in an absolute sense.

Social security: means of achieving material and non-material manifestations to meet basic needs in a secure manner and enjoy freedom from threats of violence, prejudice, oppression and environmental risks.

Subsidiarity: the process of institutional change that devolves decision-making authority to the lowest appropriate level, ensuring that the power and resources to make such decisions meaningful ones are similarly devolved.

Sustainable development: a change of living conditions that meets the needs of the present without comprising the ability of future generations to meet their own needs.

Sustainable management: management that makes best use of present resource potentials and does not diminish the availability of these resources in the future or the integrity of the ecosystems through which these resources are provided.

Sustainable use: use of an organism, ecosystem or other renewable resource at a rate within its capacity for renewal.

Vulnerability: extent to which livelihoods are at risk from factors, trends and shocks beyond their control.

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Annex 1 The Current **State** of Affairs

A1. ECOSYSTEM FUNCTIONS AND THEIR VALUES

A1.1 Ecosystem functions

Healthy freshwater and coastal ecosystems perform a number of functions, as detailed in Table A.1. A number of such functions are obvious to people: we use water to drink, grow and prepare food, provide for domestic and industrial needs (including waste disposal), generate power and transport people and goods. However, other less obvious goods and services are also provided by ecosystems, and the appropriations made for one single use often compromise the functioning of these other services.

The ability of healthy ecosystems to perform these functions can be considered the very basis of security for individuals and societies. A loss of these functions can often be directly linked with a loss in security of some individuals or society as a whole. A clean and healthy wetland, for example, has a certain purification capacity that depends on the plants and organisms and the environmental processes it sustains. Contamination of a wetland, and subsequent loss of key species and processes, will degrade this regulation function once a certain threshold is reached. To sustain ecosystem functions requires the conservation of the integrity of the ecosystem; that is, the full range of interactions between the water cycle, individual species and biophysical, chemical, and ecological processes.

A1.2 Monetary value of freshwater and wetland functions

Many functions of freshwater ecosystems and wetlands have direct and indirect economic importance. Entire communities and countries depend on the functions provided by freshwater ecosystems and, as such, ecosystems have enormous value. It is still difficult to translate this value into monetary terms, leading to the continuing loss and degradation of water systems due to undervaluation and neglect in economic accounting procedures. In Nigeria, for example, after pouring US$ 3 billion over two decades into the construction of dams for irrigated agriculture in the Hadajia-Nguru river basins, the government realised in the early 1990s that the net economic benefits of the floodplain are much larger than those from irrigated land: US$ 32 versus US$ 0.15 per 1,000m³ of water, not including benefits of floodplains inundations for groundwater recharge and water supply to Lake Chad (Adams 1992).

A first attempt to synthesise existing knowledge on the monetary benefits of the services of ecosystems on a global scale was published in 1997 (Costanza et al. 1997). Table A.1 gives a summary of the main functions, and monetary values, of freshwater and wetland ecosystems.

Table A.1 Global monetary values of freshwater and wetland functions (in US$ billion, 1994)

Ecosystem functions (goods & services)	Active or Direct Use Values (mainly market prices)	Passive or Indirect Use Values (mainly shadow price)	Percent of Global Total (for a particular function)
1. Regulation Functions			
1.1 Climate regulation & biogeochemical cycling (e.g. CO_2)	?	44	3 %
1.2 Water buffering (e.g. flood prevention)	350	350 (a)	40 %
1.3 Waste treatment	?	5,300	31 %
1.4 Biological control	?	14	3 %
2. Habitat Functions			
2.1 Refugium function	?	(c)	(c)
2.2 Nursery function	62	62 (a)	100 %
3. Production Functions			
3.1 Water	840	840 (a)	99 %
3.2 Food (mainly fish)	186	(b)	13 %
3.3 Raw materials & energy	40	(b)	6 %
3.4 Genetic material & medicines	(d)		(d)
4. Information Functions			
4.1 Aesthetic information (e.g. views)	?	5	2 %
4.2 Recreation and tourism	304	(b)	37 %
4.3 Cultural values (e.g. art, science)	(d)	(d)	(d)
Total (in US$ billion/year)	**1,782**	**6,905**	**Average 26%**

Functions based on de Groot, 1997; values based on Costanza et al., 1997

Notes:
(a) The total value of the flood prevention, nursery function and water supply given in Costanza et al. (1997) was based on a combination of market and shadow prices. For simplicity, it has been estimated here that 50% of the calculated indirect value is included in market prices.
(b) The values given for food, raw materials and tourism are based only on market prices. However, these resources also have an unknown (direct) consumptive use value (many people depend on freshwater systems for these resources directly, without market intervention).
(c) In addition to active and passive use values, many ecosystem functions have so-called non-use or intrinsic value. In this study it is not attempted to place a monetary value on the intrinsic importance of nature but it could, in part, be derived from the money people are willing to donate to conservation organisations to maintain the refugium function of natural ecosystems.
(d) Freshwater and wetland systems are important sources of genetic material, medecines and cultural values but little or no information is available on the monetary value of these ecosystem functions.

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Table A.1 shows that, worldwide, freshwater and wetland systems account for approximately 26% of the total economic value of all ecosystem services (which vary substantially by function, as the last column shows). It can be concluded that still only about 20% (US$ 1,782 billion) of the economic value of coastal and freshwater systems is accounted for in market pricing mechanisms. All other values, which mainly relate to regulation and habitat functions, are not (properly) accounted for. Damage to these functions is seen as 'externalities' (e.g. climate regulation, waste treatment, biological control and nursery habitat) and the costs associated with these function losses, such as health damage, costs of water purification and rehabilitation of freshwater systems, are (often) burdened upon poor people and future generations. A World Bank study, for example, shows that approximately 20% of families affected by dam projects in Latin America earn less than the minimum wage (Cernea 1999).

Externalities

As mentioned above, an important cause of the loss of freshwater systems is the (over-) use of the marketable functions, like water extraction, food harvesting or recreation, which are depleted at the expense of all, or most, other functions of the ecosystem in conventional market economics. These damages are still seen as 'externalities' and are therefore not included in (traditional) cost-benefit analysis. As a result, large development schemes, like dam construction and canalisation of riverbeds, have very high 'hidden' environmental and social costs that only become visible after construction and often lead to grave 'side effects' and even disasters (e.g. flooding, diseases due to still water). In a properly managed system of water resource planning and allocation, users from all sectors must be held responsible for bearing their part in the costs of maintaining the freshwater ecosystem.

Perverse incentives

Due to the vital importance of some functions (e.g. water provision and fish production), over the years a system of subsidies has developed which is now stimulating the overuse of these resources, often at the expense of most other functions of the system. Groundwater overexploitation is an illustrative example of this practice. Low water tariffs and water-intensive crop subsidies lead to irresponsible short-term rent-seeking behaviour of agribusinesses, which causes water levels to drop in many areas of the world. These perverse subsidies lead not only to unnecessary environmental problems, but also to inequity through unbalanced access to, and ownership of, natural resources.

A2. MAIN CAUSES AND EVIDENCE OF ECOSYSTEM DESTRUCTION

A2.1 Main causes of ecosystem destruction

Although natural disasters such as floods, tidal waves, hurricanes and wild fires may cause temporary ecosystem disruption on a massive scale, the only cause of permanent ecosystem destruction is human activity. The activities that have the most impact on freshwater ecosystems, and the corresponding functions which are put at risk, are summarised in Table A.2.

Table A.2 Threats to freshwater ecosystem functions from human activities

Human activity	Impact on aquatic ecosystem	Functions at risk
Population and consumption growth	Increases pressures to divert more water and acquire more cultivated land (e.g. wetland drainage); increases water pollution, acid rain, and potential for climate change	Virtually all aquatic ecosystem functions
Infrastructure development (e.g. dams, dikes, levees, river diversion)	Loss of ecosystem integrity alters timing and quantity of river flows, water temperature, nutrient and sediment transport and delta replenishment, and block fish migrations	Water quantity and quality, habitats, floodplain fertility, sports, fisheries, maintenance of deltas and their economies
Land conversion and poor land use (e.g. wetland drainage, deforestation)	Eliminates key component of aquatic environment: loss of functions, integrity, habitats and biodiversity, alters runoff patterns, inhibits natural recharge, fills water bodies with silt	Natural flood control, habitat for fisheries and waterfowl, recreation, water supply, water quantity and quality, transport
Overharvesting and overexploitation	Depletes living resources, ecosystem functions and biodiversity (e.g. groundwater depletion, loss of fisheries)	Food production, sport and commercial fisheries, habitats, water supply, water quantity and quality
Introduction of exotic species	Eliminates native species, alters production and nutrient cycling, loss of biodiversity	Water quality, sport and commercial fisheries, fish and wildlife habitat, transport
Release of chemical and biological pollutants to water, land and air	Pollution of water bodies alters chemistry and ecology of rivers, lakes and wetlands	Water supply, habitat, fisheries, recreation
Greenhouse gas emissions inducing climate change	Potential dramatic changes in runoff patterns from increases in temperature and changes in rainfall patterns	Water supply, hydropower, transportation, fish and wildlife habitat, pollution dilution, recreation, fisheries, flood control

After Daily, 1997

A2.2 Indicators and effects of loss of ecosystem functions

The current state of five key indicators are reviewed herein to substantiate the fact that human activities are causing the loss of ecosystem functions; namely: loss of ecosystem integrity, loss of habitats, pollution, resource overexploitation and freshwater biodiversity decline.

Loss of ecosystem integrity – connectivity of freshwater habitats

Ecosystem integrity can be defined as the range of interactions between the water cycle, individual species and biophysical, chemical and ecological processes that support the organisation of an ecosystem. To preserve the integrity of freshwater ecosystems it is essential to maintain the hydrological characteristics of catchments, including the (semi-) natural flow regime, the connection between upstream and downstream sections (including coastal and marine zones), the linkages between groundwater and surface waters, and the close coupling between the rivers and their floodplains.

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Fragmentation of river systems due to dams forms the greatest threat to the maintenance of ecosystem integrity. In North America, Europe and the former Soviet Union, for example, 77% of the 139 largest river systems are strongly or moderately affected by water regulation resulting from reservoir operation, interbasin transfers or irrigation (Dynesius and Nilsson, 1994).

Other important threats to ecosystem integrity include land conversion and development of other infrastructure, such as dikes and levees. Land conversion affects the hydrology of many catchments. Destruction of forests in upper catchment areas, for example, is known to increase peak flows and reduce low flows. This results in severe flooding during some months and severe water shortages for the rest of the year. Upper catchment deforestation during recent decades has been severe in local areas in developing countries, particularly in Central America and Southeast Asia. Recent floodings in Europe and the USA have shown that disconnecting rivers from their floodplains can deprive them from the capacity to store floodwater and attenuate flood peaks, inducing great damage to human property and infrastructure. Total world flood damage between 1987 and 1996 reached up to US$ 250 billion and caused the death of at least 240,000 people.

A loss of connection between upper, middle and lower parts of a river basin, and a decoupling of the river from its coastal zone, largely affects their productivity. In addition, floods are not always detrimental; they form an essential element of a healthy, functioning ecosystem. For example, the decline in discharge of the Indus and Brahmaputra rivers due to dam construction is now causing the destruction of very productive mangrove systems in the deltas of these rivers. Continued freshwater inputs are also essential for maintaining coastal fisheries and biological diversity.

Habitat destruction caused by land conversion and infrastructure

Ecosystems provide refugia and reproduction habitat for plants and animals, thereby contributing to the conservation of biological diversity and maintenance of populations of migrating and/or harvestable species. Wetlands, for example, are of a high importance for migratory species and support important levels of biological diversity, including over 10,000 species of fish and over 4,000 species of amphibians. Some of the richest habitats for freshwater species include foothill streams, lowland rapids, peat swamps and ancient lakes. The loss of wetland habitats has been severe in many developed countries during the last century and is caused mainly by conversion to agricultural land (see Table A.3).

Table A.3 The loss of wetlands in various Organisation for Economic Cooperation and Development (OECD) countries

Country	Period	% of wetland losses
France	1900-1993	67
Germany	1950-1985	57
Greece	1920-1991	63
Italy	1938-1994	66
Netherlands	1950-1985	55
Spain	1948-1990	60
USA	1970-1985	54
World	1900-1998	50

Source: OECD, 1999

Pollution of water bodies from industry, agriculture and urban centres

Pollution of water bodies originates from industrial and urban effluents, as well as such diffuse sources as agricultural runoff and atmospheric deposition. Many countries have experienced a series of freshwater pollution problems involving domestic, industrial and agricultural wastes. Water quality is currently improving in some areas, but water contamination continues to pose serious threats to human and environmental health. Persistent Organic Pollutants (POPs) originating from pesticides and herbicides, for example, continue to be used in large quantities. These chemicals become concentrated in people and other top predators as they pass through the foodweb, causing reproductive and developmental abnormalities in humans and animals. Even more frightening is their propensity to cause genetic mutations, resulting in the potential for a perpetuation of pollution impacts through genetic inheritance.

Non-point agricultural runoff continues to load surface and groundwater with overdoses of nutrients, rendering an increasing number of sources useless for drinking water. In the United States, for example, 22 per cent of wells in agricultural areas contain nitrate levels in excess of the federal limit. In many developing countries, water quality is degrading due to pollution from domestic sources. In industrial areas, wastewater contributes increasingly to poor water quality, which has serious consequences for human and environmental health. Drinking water contaminated with human or animal excreta is the main source of many water-related diseases.

Resource overexploitation

Freshwater abstractions have increased in most parts of the world in an unsustainable manner (see Table A.4). This overexploitation of resources occurs where abstractions or harvests exceed the total renewable amount of a resource (i.e. sustainable yield). In many areas of the world, the abstraction of groundwater for domestic and agricultural use is increasingly leading to falling groundwater levels. In some cases, the decline in groundwater tables is as high as 0.5 to 5 metres per year. The overexploitation of groundwater in coastal areas in causing saltwater intrusions that render many of the remaining freshwater resources useless. Falling water tables also affect wetland areas that often depend on groundwater discharge for their maintenance.

Surface water diversions and groundwater abstractions are primarily used to irrigate land. With the application undrained water, salts enter into the soil and build up to large quantities. One-fifth of the world's irrigated land is currently estimated to be damaged by salts (Postel 1999). Upstream saltwater

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drainage forms a huge threat for downstream users, as they will add more salt to their land when irrigating and need to apply more and more water to flush the excess salt.

Exploitation of freshwater fisheries has sharply increased during recent decades in several regions. Fish constitute a major source of animal protein throughout the world, especially in many tropical and subtropical countries. Figure A.1 shows that between 1961 and 1996 worldwide freshwater fish catches increased fivefold (from 9 to 45 million metric tonnes). The greatest growth has been in developing countries, particularly those in Asia, where over the same period there was nearly an eight-fold increase. The very significant increase in the human exploitation of the natural fish resource in recent decades, and the recent local decrease in catches, indicate that freshwater fishes are being exploited at, or above, sustainable levels (Abramovitz 1996). Production of farmed fish also increased up to an average of 11 million tonnes per annum between 1993 and 1995 (WRI et al. 1998). In many cases, the production methods used in aquaculture are themselves a threat to the wild fish populations in adjacent freshwater and coastal ecosystems, as five times more 'wild' fish is used to feed farmed fish.

Table A.4 World water abstractions (km³/year) increased sharply during the last decades; abstraction and consumption for agricultural use continues to predominate. Direct human consumption currently accounts for less than 10% of total abstractions. The first line is water withdrawal; the second line is water consumption:

Sector	Assessment								Forecast
	1900	1940	1950	1960	1970	1980	1990	1995	2000
Population (million)			2,542	3,029	3,603	4,410	5,285	5,735	6,181
Irrigated land area (million ha)	47.3	75.9	101.0	142.0	169.0	198.0	243.0	253.0	264.0
Agricultural use	513.0	895.0	1,080.0	1,481.0	1,743.0	2,112.0	2,425.0	2,504.0	2,605.0
	321.0	586.0	722.0	1,005.0	1,186.0	1,445.0	1,691.0	1,753.0	1,834.0
Industrial use	21.5	58.9	86.7	118.0	160.0	219.0	305.0	344.0	384.0
	4.6	12.5	16.7	20.6	28.5	38.3	45.0	49.8	52.8
Municipal use	43.7	127.0	204.0	339.0	547.0	713.0	735.0	752.0	776.0
	4.8	11.9	19.1	30.6	51.0	70.9	78.8	82.6	87.9
Reservoirs	0.3	7.0	11.1	30.2	76.1	131.0	167.0	188.0	208.0
Total (rounded)	579.0	1,088.0	1,382.0	1,968.0	2,526.0	3,175.0	3,633.0	3,788.0	3,973.0
	331.0	617.0	768.0	1,086.0	1,341.0	1,686.0	1,982.0	2,074.0	2,182.0

Source: Shiklomanov, 1999

Table A.5 Freshwater fish extinctions globally: Number of known species extinctions by decade

	1890s	1900s	1910s	1920s	1930s	1940s	1950s	1960s	1970s	1980s	1990s
Number of extinct species by decade	2	1	0	4	2	3	4	1	8	53	3
Cumulative total		3	3	7	9	12	16	17	25	78	81

Source: WCMC, 1998

Note:
Ninety-one fish species were listed as extinct in the wild in 1996. This table includes 50 Lake Victoria cichlids, all treated here as becoming extinct during the 1980s, and 31 other species for which estimated extinction times are available. A further 10 species could not be assigned to a decade.

Loss of freshwater biological diversity

Biological diversity relates to the indigenous diversity that exists at various trophic levels, ranging from ecosystems and species to genes. Freshwater biological diversity is relatively high in relation to the very limited portion of the earth's surface covered by freshwater. Freshwater fish, for example, comprise 40% of all fishes (Abramovitz 1996) and freshwater molluscs comprise 25% of all molluscs (IUCN 1996). Freshwater biodiversity tends to be greatest in tropical regions with a high number of species, such as in northern South America, Central Africa and Southeast Asia. Worldwide, the total number of freshwater species is estimated to be between 9,000 and 25,000.

The loss of freshwater biodiversity is poorly monitored except for some larger, commercial species. Available data suggest that between 20 and 35% of freshwater fish are vulnerable or endangered. In addition, of the more than 3,500 species currently threatened worldwide, 25% are fish and amphibians (UNEP 1999). Table A.5 indicates that extinction rates increased rapidly during the eighties (from 8 in the 1970s to 53 in the 1980s), whereas during the 1990s freshwater fish species loss was reduced to three species. Habitat destruction, particularly that caused by water infrastructure development (e.g. dams, dikes), is a major cause of freshwater biodiversity loss. Other factors include pollution, invasive species and overharvesting. The loss of freshwater biological diversity affects the benefits derived by humankind, especially as many freshwater ecosystem functions are based on the presence of a range of species (e.g. plants, fishes, molluscs, insects, bacteria) that are essential for their performance.

It is estimated that half the fish stocks endemic to the Pacific coast of the USA have been wiped out in the past century, often because of dam construction (Chaterjee 1998). Serious negative environmental impacts are associated with the construction of large infrastructure such as dams. Reservoirs flood the river upstream and disrupt the natural hydrological regime of downstream freshwater ecosystems. These changes can have severe implications for downstream users, as well as flora and fauna.

A3. WATER RESOURCES DEGRADATION JEOPARDISES SOCIAL SECURITY

Freshwater ecosystem functions provide the basis for social security, which can be seen as the extent to which people are able to meet their most basic needs (water, food, shelter, health) in a secure manner, and the freedom people enjoy in the absence of violence, prejudice, oppression and environmental risks. As such, the prevention and mediation of conflicts is a key element of social security.

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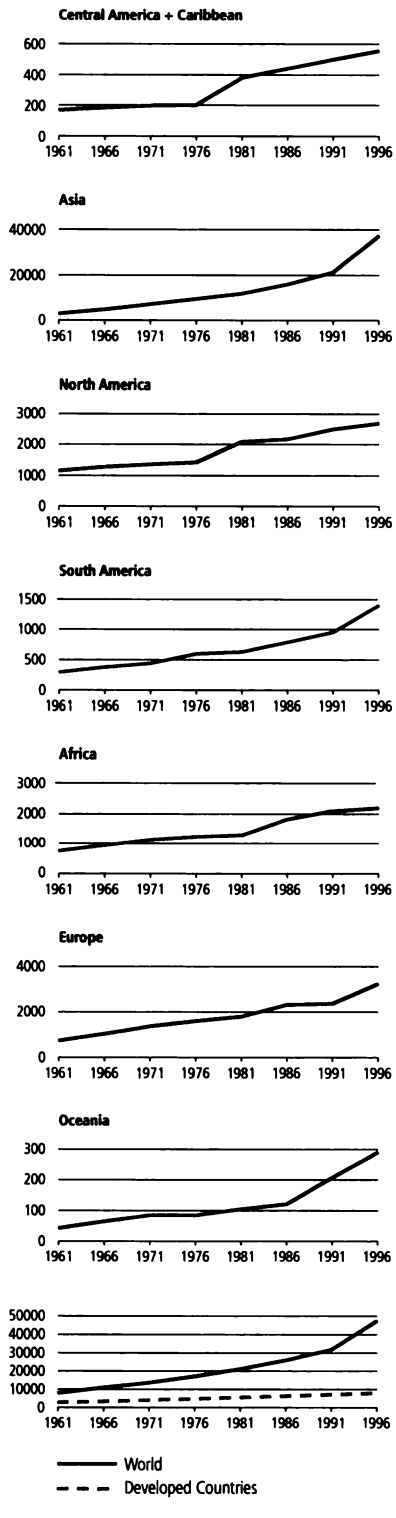
Figure A.1 Freshwater fish catches between 1961 and 1996 indicate a sharp rise in catches in Asia that currently is responsible for 76% of the total world freshwater fish catches (in MT x 1000).



Source: McCartney et al., 1999, based on data from FAO, 1999

Because water forms the most important basic human need, social security is intimately linked to the sustainable use of freshwater ecosystem functions, as detailed above. Maintaining these functions provides direct and indirect benefits to people and their security.

Considering the vital importance of freshwater ecosystems, their many functions and uses, and the degradation they are facing, it is not surprising that there is increasing conflict and social disruption related to freshwater systems. The absence of fair and effective social structures is the root of both ecosystem degradation and social insecurity. As such, the analysis of the relationship between social security and the use of freshwater ecosystems must focus on issues of conflict, power and empowerment, in relation to water resource access and distribution at all levels.

Conflicts over water resources at the livelihood level often centre around allocations between different user groups and individuals. This is directly related to the conditions of life-support systems, as they provide the means through which people secure a 'living'; that is, the ecosystem functions that allow them to survive and, for some, prosper. Allocation of land and water for irrigated agriculture, for example, is in many cases in conflict with fully fulfilling stream water requirements for ecosystem maintenance, fisheries and tourism. Without adequate mechanisms to resolve conflicts, no secure livelihood base can be provided.

At national levels, destruction and degradation of ecosystems is often the result of conflicting interests. In many cases, this leads to a water resource base being developed with a single purpose in mind, which seeks to maximise supply to a few with little regard for the impacts on equity, social security and ecosystems. Rarely do these institutions provide a forum for representative consensus-building and local empowerment, both of which are crucial to avoiding and solving conflicts between users. Such platforms for collaboration, coordination and exchange are also often absent at the ministerial level, with technical institutions being poorly linked and the division of responsibility poorly defined. The current top-down management structures tend to neglect traditional systems and, by focusing on large-scale water engineering, erode the social security of populations, often forcing them to become environmental refugees.

Conflicts over water resources also appear at international levels. Recent analysis has shown that, worldwide, over 300 zones of potential conflict over water resources exist. These conflicts are mostly related to appropriation of water by upstream countries or overabstraction of groundwater. International water conflicts are all related to potential or actual resource destruction or degradation, with one or more countries involved. The result of upstream overabstraction is that countries downstream, or those without enough resources to dig deeper wells, are faced with rivers and wells drying up. Pollution of rivers and aquifers is another important area for international conflict. This goes to show that, at all levels, there exists a close relationship between water resource degradation and security for people and nations.

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Annex 2 Selected International Agreements and Texts Related to Environmental Aspects of Water Resources Management

Convention on Wetlands (Ramsar) (1971)

The Convention on Wetlands is the first of the modern global intergovernmental treaties on conservation and wise use of natural resources, and today covers all aspects of wetland conservation and wise use. It recognises wetlands as ecosystems that are extremely important for biodiversity conservation and for the well-being of human communities. The Convention on Wetlands entered into force in 1975 and now has more than 110 Contracting Parties in all parts of the world. Under Article 3.1 of the Convention, Contracting Parties agree to: "formulate and implement their planning so as to promote the conservation of the wetlands included in the List, and as far as possible the wise use of wetlands in their territory."

UN Water Conference (Mar del Plata) (1977)

This was a 'historic conference' and the first, and so far the only, UN conference entirely focusing on water. In the Mar del Plata action plan, recommendations are discussed in detail. In retrospect, the implementation of the action plan has been far from satisfactory. It did, however, urge for the launching of the International Drinking Water and Sanitation Decade, stating:

It is necessary to evaluate the consequences which the various uses of water have on the environment, to support measures aimed at controlling water-related diseases, and to protect ecosystems (35). ... take into account the need for improvement of catchment areas of the national hydrological basins which generate the water resources to be used, in keeping with their degree of degradation and provide for the costs of such measures (36c). ... recognize that freshwater and coastal wetlands are among the most vital and productive of ecological systems (36m).

UN World Charter for Nature (1982)

The World Charter for Nature was adopted by consensus by the UN General Assembly in 1982. It provides the high-level guiding principles that should govern humankind's responsibility for nature conservation and management. In its preamble, it states that:

Every form of life is unique, warranting respect regardless of its worth to man (sic), and, to accord other organisms such recognition, man must be guided by a moral code of action and that man can alter nature and exhaust natural resources by his action or its consequences and, therefore, must fully recognise the urgency of maintaining the stability and quality of nature and of conserving natural resources.

The general principles of the World Charter for Nature are:

- Nature shall be respected and its essential processes shall not be impaired.
- The genetic viability on the earth shall not be compromised; the population levels of all life forms, wild and domesticated, must be at least sufficient for their survival, and to this end necessary habitats shall be safeguarded.
- All areas of the earth, both land and sea, shall be subject to these principles of conservation; special attention shall be given to unique areas, to representative samples of all the different types of ecosystems and to the habitats of rare or endangered species.
- Ecosystems and organisms, as well as the land, marine and atmospheric resources that are utilised by man, shall be managed to achieve and maintain optimum sustainable productivity, but not in such a way as to endanger the integrity of those ecosystems or species with which they coexist.
- Nature should always be secured against degradation by warfare or other hostile activities.

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Activities which might have an impact on nature shall be controlled, and the best available technologies that minimize significant risks to nature or other adverse effects shall be used; in particular:

- *Activities which are likely to cause irreversible damage to nature should be avoided;*
- *Activities which are likely to pose a significant risk to nature shall be preceded by an exhaustive examination; their proponents shall demonstrate that expected benefits outweigh potential damage to nature, and where potential adverse effects are not fully understood, the activities should not proceed;*
- *Activities which may disturb nature shall be preceded by assessment of their consequences, and environmental impact studies of development projects shall be constructed in advance, and if they are to be undertaken, such activities shall be planned and carried out so as to minimize potential adverse impacts.*

These guiding principles have been reaffirmed in a succession of formal intergovernmental agreements.

International Conference on Water and Environment (Dublin) (1992)

Five hundred participants endorsed four guiding principles in the Dublin Statement:

1. Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.

2. Water development and management should be participatory, involving planners and policy makers at all levels.

3. Women play a central role in the provision, management and safeguarding of water.

4. Water has an economic value in all its competing uses and should be recognised as an economic good.

Not only must the Vision for Water and Nature pay due attention to the description of the future state of the world's freshwater ecosystems as we hope to see them 25 years from now, but it must also consider the economic tools, policies, and constraints that must be dealt with in order to achieve that desired vision. A great deal of thought and progress on these issues is already contained in the product of the UN Conference on Environment and Development, Agenda 21, Chapter 18.

Koh Kheng Lian
Singapore
Economic Security Workshop Chair

Since water sustains life, effective management of water resources demands a holistic approach, linking social and economic development with protection of natural ecosystems. Effective management links land and water uses across the whole of a catchment area or groundwater aquifer.

UN Conference on Environment and Development (1992)

Links between the environment and development were recognised at the highest political level during the formulation of Agenda 21, consisting of 40 chapters. Freshwater resources is dealt with in Chapter 18 and lists seven programme areas. Most of the seven programmes cover the same issues as the eight recommendations in Mar del Plata, with the exception of urban issues and climate change.

Agenda 21, Chapter 18 – Integrated Water Resources Management, states:
18.8 Integrated water resources management is based on the perception of water as an integral part of the ecosystem, a natural resource and a social and economic good, whose quantity and quality determine the nature of its utilization. To this end, water resources have to be protected, taking into account the functioning of aquatic ecosystems and the perenniality of the resource, in order to satisfy and reconcile needs of water in human activities. In developing and using water resources, priority has to be given to the satisfaction of basic needs and the safeguarding of ecosystems. Beyond these requirements, however, water users should be charged appropriately.

Agenda 21, Chapter 15 – Conservation of Biological Diversity, states:
... processes and activities with significant impacts upon biological diversity [should be identified;...] *action* [should be taken] *where necessary for the conservation of biological diversity through the in situ conservation of ecosystems and natural habitats* [;... and] *the rehabilitation and restoration of damaged ecosystems and the recovery of threatened and endangered species* [should be promoted.]

The Convention on Biological Diversity (CBD) was signed by 156 States in June 1992, and by September 1999, 175 countries had ratified the Convention.

UN Expert Meeting on Water Management (Harare, Zimbabwe) (1998)

The Expert Group Meeting recalled Agenda 21, Chapter 18, to be a basis for action concerning freshwater and states:
III.D.I. Ecosystem integration. The conservation of freshwater and related ecosystems is vital to sustainable development. These ecosystems are themselves users, water regulators and providers of freshwater-based resources (including fisheries). It is therefore necessary to promote an ecosystem approach in integrated water resources planning, development and management within the framework of river basin and aquifer systems.

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Freshwater Ecosystem Management & Social Security

Discussion Paper

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Acronyms

BMC	Brihanmumbai Municipal Corporation
CSD	Commission for Sustainable Development
CWW	Conventional Water World
FAO	Food and Agriculture Organisation
IUCN	International Union for the Conservation of Nature
NGO	Non-governmental Organisation
OECD	Organisation for Economic Cooperation and Development
OPP	Orangi Pilot Project
SEI	Stockholm Environment Institute
SWW	Sustainable Water World
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNIDO	United Nations Industrial Development Organisation
WC	Water Crisis
WHO	World Health Organisation
WMO	World Meteorological Organisation
WRI	World Resources Institute

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1. Introduction

This paper is about freshwater ecosystems and social security: two issues that are not obviously linked, but that together represent key issues for the future of humankind and our planet. Understanding these relationships requires some new approaches, new ways of thinking about familiar issues. The management of freshwater ecosystems is widely discussed, but mostly from either a production perspective (how to maximise the utility of their management for specific purposes such as irrigation, drinking water or fishing) or an ecological perspective (how can these ecosystems be managed in ways that do not affect their ecological integrity). Their role in the maintenance of social security and the social and institutional processes through which this role is reproduced are notable by their absence from much of the literature.

It is these issues that this paper considers. The report itself has been prepared as a background paper for an IUCN-sponsored workshop on freshwater ecosystems management and social security, and as such it is intended to stimulate thought and discussion amongst the participants. To do this, the paper starts out by presenting a conceptual framework for the consideration of these issues. This framework includes a consideration of what is meant by social security and then considers the societal processes through which it is created. This starts at the level of the individual and household, adopting a livelihoods approach, and analyses the institutional processes through which people and communities are linked together and to the outside world.

The paper then discusses, through a series of case studies, freshwater ecosystems management and social security in the modern world. It is hard to generalise on issues that are so specific to different places and times, but lessons are drawn from the case studies to identify the types of processes that could help find the balance between maintaining the integrity of the ecosystems and guaranteeing their role in social security systems.

The fourth section looks at the future, basing an analysis on three scenarios developed for the overall IUCN initiative on Water and Nature. These scenarios indicate the uncertainties the world faces as we enter a new millennium; uncertainties that make the maintenance of social security systems all the more important.

The paper then considers strategies for the future, first outlining approaches that can address the structural issues of institutional processes that underlie water-social security relationships and then considering some adaptation and mitigation strategies that are appropriate for specific challenges. Next, the paper then raises a few broad questions that provide a basis for considering the issues that the workshop should address. Finally, a list of references and a glossary are annexed, with the latter presenting definitions for many of the terms and concepts used in this paper.

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2. Towards a Conceptual Framework

2.1 Introduction

The discussion presented in this paper centres on the relationship between social security and the management of freshwater resources. These are complex and only hazily-understood issues, and the specific form these processes take in different places will vary greatly. The characteristics of the freshwater ecosystems of different parts of the world are closely linked to local environmental conditions, while social security issues are part of the wider social, cultural and institutional context of an area. The link between the two is not obvious but is real nonetheless. A secure and stable social context provides the setting within which good management practices can emerge and the integrity of freshwater ecosystems can be preserved. At the same time, the benefits and services that these resources provide can be important in creating social security. Conversely, the absence of conditions in which people feel secure can lead to environmental devastation, whilst declining access to freshwater resources (through their degradation or increasing demands) can create conflicts and undermine to integrity of the mechanisms through which social security is created.

There is a need to give structure to these complex issues through the development of a conceptual framework that helps understand the many factors any analysis of these issues needs to take into account. Such a framework is presented in this section. The starting point is to understand what social security is and why it matters for the management of water resources and the ecosystems through which they are available. What is not here is an attempt at a comprehensive review of social security or the institutions that regulate the use of freshwater resources, for such a review would be far beyond the scope of a background paper such as this. Such issues are extremely specific to individual times and places and any generalisation will be inherently simplistic. Instead, we present here an approach that can be applied to specific places and societies, illustrating this approach (where possible) with some examples that are intended to stimulate thought rather than 'prove' anything.

2.2 Social Security

Social security is experienced by individuals but produced within societies. It is a set of rights and entitlements, and the social and institutional structures through which these are reproduced and made available, that reduce vulnerability to risks and threats beyond the control of individuals. It has material and non-material manifestations, including both the extent to which people are able to meet their most basic of needs (things such as water, shelter, good health and food) in a secure manner and the freedoms people enjoy from threats of violence, prejudice, oppression and environmental risks. Although generalisations are difficult, there are some common elements to social security that are valid around the world. These include the protection of health, basic systems to care for the most vulnerable (such as children and the elderly) or to cope with catastrophes (such as environmental disasters or the loss of key livelihood assets), a basic level of security of income (in whatever form), the freedom from overt oppression and violence and certainty over land, water and other rights. For both the material and the non-material, the greater the security the less vulnerable people are to such trends and shocks.

This is directly reflected in the way that society is organised to manage resources and provide for needs. At all levels from the individual to the international (and in an age of globalisation the latter is increasingly important), people interact with each other and the environment through established and understood rules and institutions. These structures provide the benefits that working together brings and are a means through which any conflicts can be resolved. Their effect is mostly implicit: we are all largely self-regulating in the ways we behave with each other and the environment, and most people feel more secure when they know the 'rules of the game' and feel that their needs and rights are represented in these regulatory processes. Where either individuals or groups break the rules, where they act in ways that hurt others or the resources, these regulatory processes can (or should) provide sanctions that curb their behaviour and proscribe destructive courses of action.

Of course, this ideal is often not true: we live in an unequal world in which individuals and groups are able to impose their wants and actions on others. This can be by brute force: the force of arms or the overwhelming power of the majority imposing on a weaker minority. It can be through the institutions that are set up to regulate society: the effects of laws that define 'ownership' or prescribe what can or cannot be done and the operation of government and other agencies that are meant to implement the rules. It can reflect economic power, where the operation of markets and unequal distribution of wealth provides control for some at

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the expense of others. Or it can be through the lack of societal institutions: where the actions of some may harm others (perhaps downstream in a catchment) but there are no effective mechanisms to control their actions (or perhaps to even understand the implications of their actions), even where there is a desire to.

This absence of fair and effective social structures is the root of both ecosystems degradation and social insecurity. As such, any analysis of the relationship between social security and freshwater ecosystems management must inevitably focus on issues of power and empowerment, and build this discussion on an analysis of the societal processes through which individuals and groups lead their lives and are linked to each other.

This in turn is in large part a function of the societal processes through which people are able to minimise risks and control their own lives. This obviously matters to people. It also matters to ecosystems, as resource degradation is often the result of responses to risks or the impact of shocks that undermine people's security. These can take many forms. The most overt and catastrophic can be war or civil strife that destroys both people and environments. We only have to think of the Gulf War, Vietnam or the many bitter struggles found in Africa over the last thirty years to see just how devastating such conflicts can be. Here and elsewhere, conflict has destroyed ecosystems as surely as it has shattered lives.

Though terrible, however, these are by no means the only forms that vulnerability takes. There are many types of vulnerability and conflict that undermine people's social security and affect ecosystems viability. How can we understand them? The best starting point is to understand people's lives, how they are linked to social institutions and how this affects the management of ecosystems'. This can be analysed within a livelihoods framework, an analytical model that gives us a starting point. This approach is then developed to understand the relationship between individuals and households on the one hand, and the wider structures of society and institutions within which people and families live and social security is channelled.

2.2.1 Livelihoods

The concept of livelihoods is gaining increasing acceptance as the basis of approaches to understanding the factors that influence the lives and well-being of people, and especially the poor, of the developing world (Carney, 1998; Davies, 1996; Bernstein et al., 1992). The concept itself has many meanings and is, like many new but hazy conceptual bandwagons, amenable to abuse as people try to present the old wine of conventional approaches in the new bottle of fashionable development rhetoric. There is a need to bring some clarity and conceptual rigour to this potentially formidable concept. The model presented here is a contribution to this process. There are many different definitions of livelihoods, but Carney (1998) presents one based on the work of Robert Chambers and Gordon Conway that is better than most:

> *A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base* (Carney, 1998; 4).

The goal of the model presented in Figure 1 is to provide a framework for tracing the inter-connections between the different aspects of people's livelihoods and the factors that influence them. This is the first key point – in the model, as in livelihoods, the key is not the different parts (the boxes) but the links between them (the arrows).

The whole concept of livelihoods is based around the dynamics of the means through which people secure a 'living': that is, the goods and services that allow them to survive and, for some, prosper. The second key concept is that livelihoods are complex. There is an increasing recognition that the livelihoods of people (and especially households) in the developing world are based around a wide range of activities: people are not just farmers, or labourers, or factory workers, or fisherfolk. Most families base their livelihoods around complex strategies that seek to maximise the use of the bundle of resources and assets they possess or have access to: "rural families increasingly come to resemble miniature highly diversified conglomerates" (Cain and McNicoll, 1988, quoted in Ellis, 1998).

The third dimension of the approach is that livelihoods are influenced by a wide range of external forces, both within and outside the locality in which a household lives, that are beyond the control of the family. This includes the social, economic, political, legal, environmental and institutional dynamics of their local area, the wider region, their country and, in an era of increasing globalisation, the world as a whole. Its effects are felt by all, including people living in the remotest parts of the developing world. These external forces are themselves not static; indeed, it is their dynamics, the processes of change in the wider economic, social and natural environment, that create the conditions in which livelihoods change. These changes can be longer-term trends: for example, changing attitudes to gender roles in a society or the gradual decline in fish stocks in a lake. They can also be sudden shocks: the impact of a war, a hurricane or the collapse of market prices for a key crop.

In general, the poorer a household is, and in particular the less assets it possesses, the more vulnerable it is to disruption in its livelihoods base from these shocks and trends (what can be called the vulnerability context). Indeed, in a livelihoods context this is almost tautologous: vulnerability is both a condition of and a determinant of poverty.

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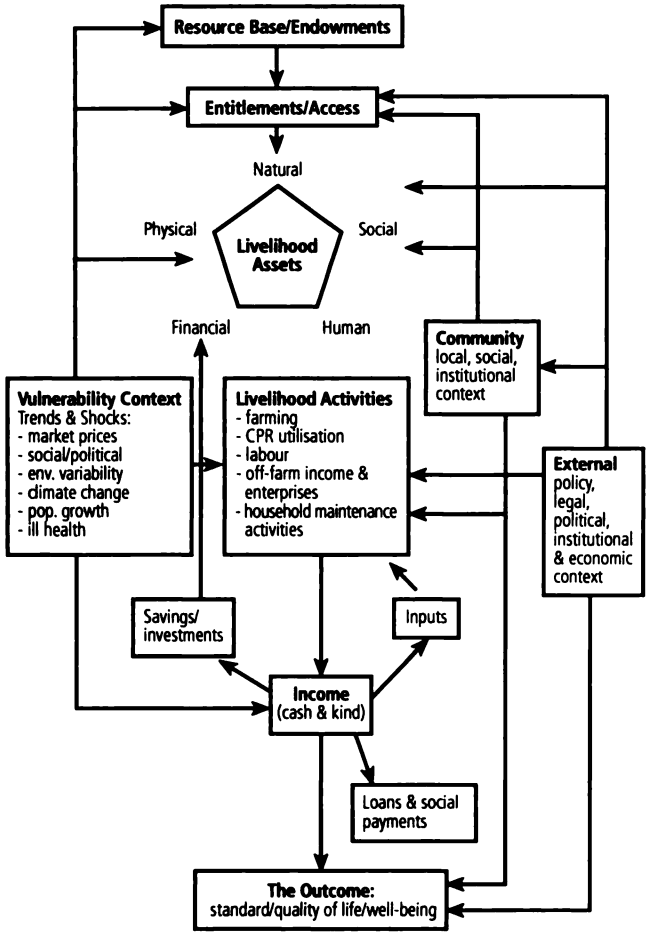
Figure 1 A Model of Livelihoods Processes and Influences



The strategies that the poor, and others, adopt in the face of such threats are often called coping strategies. In these, the household will seek to deploy the different assets they possess to best effect within the (often limited) range of choices they possess. This set of choices is again conditioned by the wider context within which they live, and in particular by the extent to which they can control the key decisions that affect their lives. It also reflects their social and institutional context and their knowledge systems. This includes practices and perceptions that relate directly to social security and to freshwater ecosystems management, such as existing notions of health and well-being and traditional systems (formal and informal) for the management of and rights to water resources. These existing institutional and knowledge systems set a context within which people will act and which are often poorly understood (or ignored altogether) by external agencies. This is (or should be) why participation is widely advocated: it is about giving the most vulnerable greater choices to meet the risks they face, and ensuring that these choices reflect the realities of life within which they exist.

The counterpart of vulnerability is resilience: that is, the extent to which livelihood are able to withstand shocks and still prosper. This resilience, of course, reflect assets (or wealth), but it is also a function of the diversity of the livelihood system. A wider range of livelihoods activities and assets will give greater choices, which in turn means that disruption to one aspect of life does not disrupt the whole system. Resilience is also derived from the social context in which people live, as the ability to cope with shocks and change frequently relates to the access that social structures and contacts give to livelihood opportunities. In particular, there are often sophisticated sets of mutual obligations (what is sometimes called reciprocity) within social groups that govern the types of assistance that people give each other in difficult times. As a rule, the more extensive and established the social context of people, the more resilient both their livelihood and the social structures are to disruption.

These basic concepts can be traced through the flows shown in Figure 1. The figure contains a central spine that represents the livelihood dynamics of a household, individual or social group. This central spine is the flow from the entitlements and access they possess to the resource endowments in their locality through their livelihood assets to the set of livelihood activities that generate an 'income' (both cash and kind).

This income is, in turn, allocated to saving or investments that enhance the value of the assets, and go towards paying for inputs (fertilisers, raw materials, labour) that go into production, to repaying loans or social payments (taxes etc) or, finally, to consumption – the outcome – that is, the total set of goods and services that constitute the material fabric of people's lives. Obviously, the greater the income, the more that is left after other obligations are met (inputs and social payments) for either consumption (meeting the needs of today) or investment (increasing the ability to meet needs tomorrow). Of course, other factors contribute to well-being, including the social context within which one lives, a sense of freedom and security and many other non-material factors. Despite this, there is no doubt that the root of the 'development challenge' that we all face is poverty: that is, the inability of people's livelihoods to provide them with an adequate and reliable income to meet their needs, now and in the future.

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2.2.2 Social and Institutional Processes

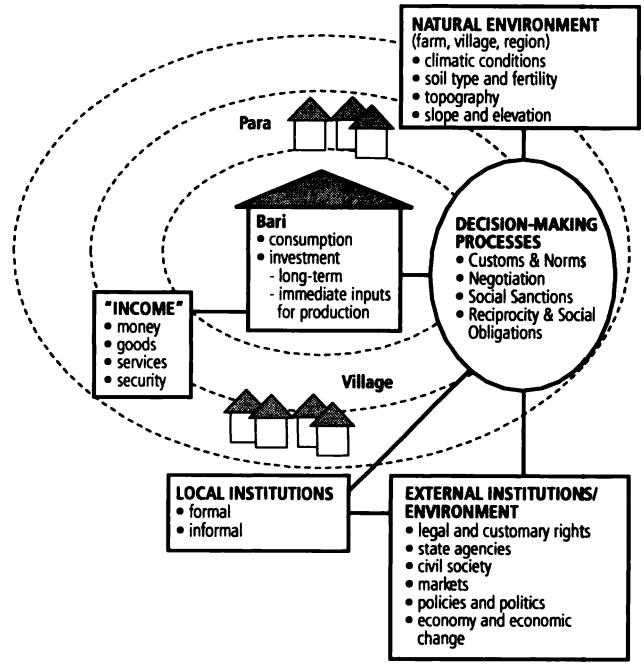
The central core of the model in Figure 1 reflects the internal dynamics of a livelihood system, but it is clear that this process does not operate in isolation from a wide range of influences that condition the flows through the livelihood, the choices available at any stage and the overall outcomes of the livelihood. The first factor is the local community: the social groupings that the individual household lives within. The social and institutional structures of local communities are often extremely complex and locality-specific, but they reflect differing combinations of the place (the locality or neighbourhood) and the people (the kin, religious, ethnic, occupational grouping or other social and economic characteristics) where an individual household lives. Figure 2 gives an example of the internal structure of such a community, with the internal differentiation shown and the need to relate these internal social structures to decisions over resource allocation emphasised.

The second conditioning factor that affects livelihoods is the external context: the legal, political, social, economic and institutional environment; those factors, in others words, that link people and places into regional, national and global systems. This includes the nature and operation of government (which can have both direct effects, such as through agricultural subsidies or health services, and indirect impacts through policy and macro-economic frameworks, political climates, etc), the structure and strength of civil society (those non-state institutions and organisations that also regulate social and economic processes), the operation of markets and so on.

These local and external social structures in many ways define the characteristics of the different parts of the livelihood model. For example, entitlements and access to an area of forest to gather products such as fuelwood and fodder can reflect both the legal and policy framework (which define who owns the forest and what form of external regulation exists) and local customs and traditions concerning what can be gathered by whom. This in turn defines a part of the 'natural' capital in the 'livelihoods assets' pentagon. Similarly, both external monetary policies and financial institutions and local moneylenders define the availability and cost of credit, which is crucial in both determining how much income goes to repay past loans and what credit is available for investments and inputs into production.

Finally, the vulnerability context has already been referred to. This is the trends and variability in those factors that affect livelihood processes. Most are not different to the local and external context described above: rather, they reflect the dynamics of those contexts. As such, the vulnerability context describes processes that can materially disrupt different aspects of the livelihood process. This can be specific: for example, climate change will directly affect the resource base, with other consequences compounding through the system from there. It can also vary, depending on form or timing. For example, a sudden collapse in market prices for a dominant commercial crop can affect the assets available by making key assets of land and agricultural implements less valuable. It can affect the livelihood activity through leading to a decision to plant something different. Or it can affect income if the price collapse happens after planting.

Figure 2 The Structure of Local Communities in Rural Bangladesh



The model shows the structure of local society in a village in central Bangladesh. Individuals live in family-based households, with typically 2 to 3 generations under one roof. These households are grouped (socially and spatially) in clusters of up to 10 families living in a 'Bari,' which is based on kin and social group lines (including caste for Hindus). The Bari is a key decision-making unit for many aspects of resource allocation, including choices over common property resource management. Baris are grouped into 'Paras': larger groupings that are again socially and spatially clustered, but their internal social structure often contains hierarchies and clear patron-client relationships over land and labour allocations. Some contain distinctive occupational groups such as potters or weavers. A group of Paras form a village, which may have several blocks of housing separated by fields and water bodies. Villages are typically administrative units (and hence the main point of interaction with the state), but also often contain central points where markets, services, etc. are available (that is, interaction with the wider civil society). A 'village' is consequently a complex construct, with different social units according to different aspects of life. Understanding where decisions are made and how these interact with local social relations is a key to effective participation and empowerment.

Source: Soussan et al., 1998

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The model shown in Figure 1 allows one to 'map' the consequences of specific changes, including changes brought about through external interventions intended to improve people's lives. An example can illustrate this. A dominant approach to natural resources management in recent years has been participatory mobilisation to create community-based institutions to manage common property resources. Initiatives such as community-based management of mangroves in Sri Lanka (Ganewatte, 1997), St. Lucia (Burt and Hudson, 1997) and elsewhere typify this approach. Their points of intervention and impact can be 'mapped' on the livelihoods model.

- The most complete of such initiatives are based on a redefinition of the external policy and legal context, with new laws that change tenure and/or access rights and new mandates for government forestry or environment departments.
- The approach also seeks to change the local social context, both through raising awareness and understanding and by creating new local institutions (community-based user groups or management committees).
- Through this medium, community management changes the entitlements and access of individual households to the mangroves. The effects on this will vary from household to household, depending on existing dependence on the mangrove, but in general it is assumed that more secure rights lead to better management practices.
- The combination of better access to the resource base and new institutions usually has a positive effect on the natural and social livelihood assets of the households if the community management is both egalitarian and effective.
- This in turn means that livelihood activities such as fuelwood gathering or fishing will be more productive and/or sustainable.
- The sustainable income will consequently be improved, with fewer concerns about gathering different products from the mangroves.
- All of these factors together mean that the household's vulnerability to declining mangroves, shortages of fuel and food, and dangers of storm damage and other hazards from mangrove destruction are all decreased.
- These reduced pressures can have a positive impact on the common property resource base and endowments, with improvements to mangrove conditions widely observable where successful community management develops (Vannucci, 1997).

As such, the effects of changes to the legal framework and the organisation of community-based groups can be traced through the model to analyse cause and effect. The details of the effects on individual households (or stakeholder groupings within the community) can similarly be mapped, to assess the consequences of variations in needs and participation. The impacts of negative developments could similarly be mapped: for example, the immediate and longer-term impacts of the 1998 floods in Bangladesh on different stakeholder groups.

Finally, each of the boxes in the model could be 'unpacked' – further elaborated to give an understanding of the internal structure and dynamics of that part of the system. This is done in Figures 3 and 4 for the external institutional structures and inter-relationships, for these define the processes through which local places interact with the wider world. This in turn is crucial in determining many aspects of social security.

Figure 3 represents a typical institutional situation in many parts of the developing world. It is characterised by strong top-down links within different institutions (especially government organisations), poorly-developed horizontal links between institutions at any level and poor links between the local level and external institutions. Local government also tends to be weak, both internally and with regard to integration with either other institutions or the local level. Finally, those institutions that do connect with the local level (private sector enterprises, some non-governmental organisations [NGOs], some civil society institutions) are extremely variable within and between countries and communities.

This poorly-developed institutional framework is itself part of the development challenge. There has been a lot of attention in many development initiatives to the issue of 'institutional capacity building.' What does this mean? Figure 4 sets out what should be the goal of such initiatives. Firstly, there are far stronger horizontal links between different types of institutions (and especially between state and non-state institutions) at all levels. This crucially includes the district, sub-district and local levels, the arena of local government where the poor come into direct contact with external agencies.

Secondly, these stronger horizontal links are complemented by more complete and different vertical links, with more effective penetration down to the local community level and the move from top-down flows to two-way interactions. In particular, there should be a process of devolution of decision-making authority to lower levels, where the people affected by decisions can directly influence or participate in them.

Thirdly, the relative strength of central government ministries is diminished and that of local government and civil society strengthened. This means that there is better scope for decisions to be made at the right level (the concept of subsidiarity), and in particular for institutions to be more open, accessible and accountable to local communities and the wider society. It also means that there is better integration of different interests in decision-making, which in turn will reduce the risk of conflicts over resources management and create the structure for the arbitration of conflicts where they do emerge.

A key characteristic of existing patterns of resource allocation and social relations is the potential for overt or repressed conflict. Such conflicts can be direct and material: for example, disputes over access to common property wetlands between fisherfolk or herders (who want to retain their existing characteristics) and farmers (who want to drain them for farmland that then becomes a private resource).

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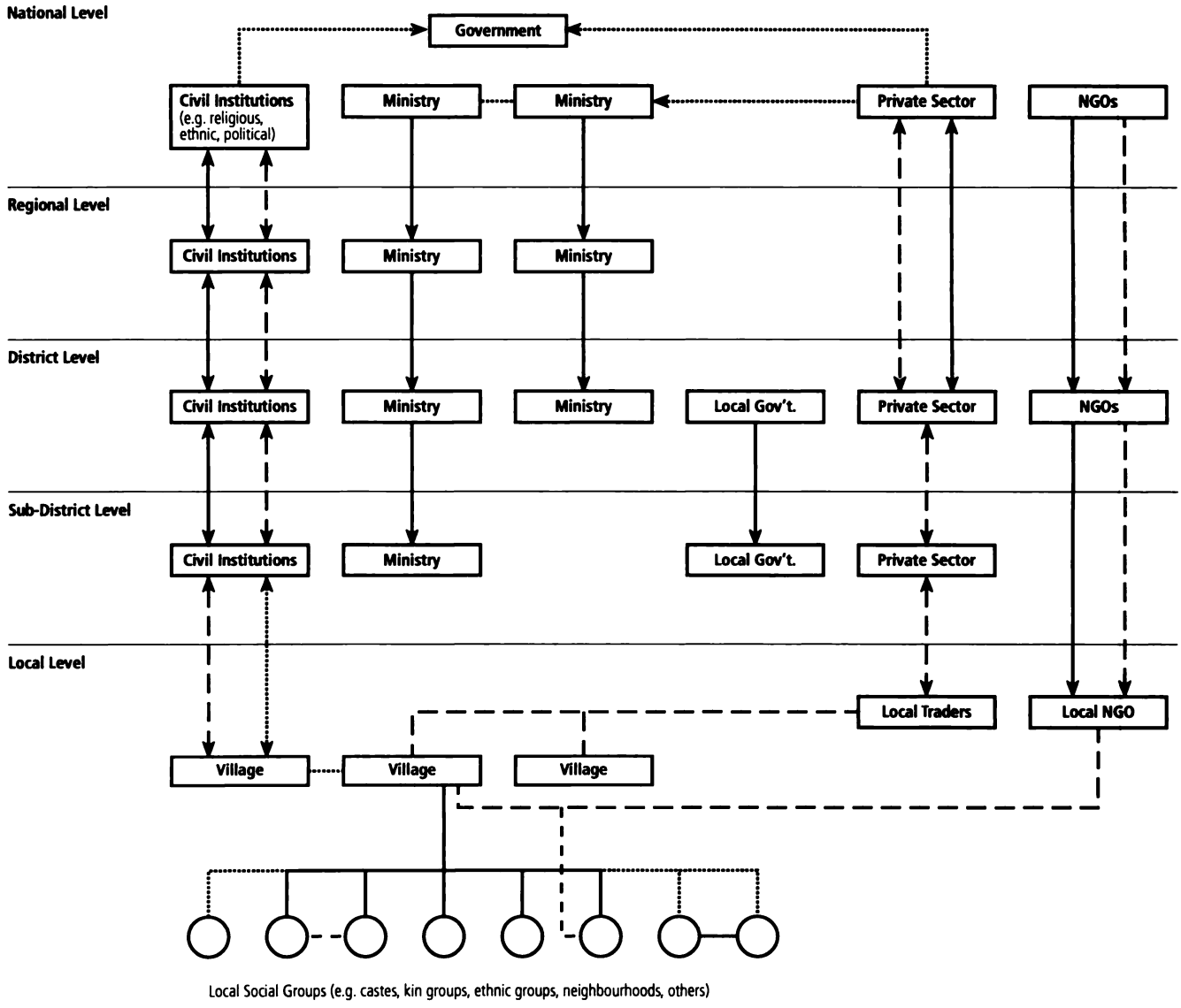
Figure 3 Existing Local to National Institutional Relationships
(Typical situation, with strong vertical and weak horizontal links and poor local-external links)



They can be structural and reflect inherent power relationships between genders or social groups (reflecting, for example, the gender divisions of labour in rural production and household maintenance). An essential feature of effective institutional processes is the capacity to mitigate such conflicts in ways that are fair, transparent and accepted as legitimate by all parties.

In other words, the goal of the process shown in Figure 4 is the more complete integration of people and local communities into the wider institutional structures of society. This process of integration can take many forms, and in particular does not mean a prescriptive plan, administered by some sort of super agency, which aims to control all aspects of the process, or even formal organisational links and unified chains of command. Integration is above all about the harmonisation of existing policies, programmes, laws and institutions. It is about moving from traditional sectoral approaches that address just part of the picture to a unified approach that addresses the whole picture. An integrated approach should seek to build on what is there, on the social processes and institutions through which social security is provided and freshwater ecosystems are managed. The key to this is to create a common understanding and to construct processes for consensus building and representation that take account of the needs and interests of all groups within the society. These themes are developed below, and represent one of the key challenges that this paper seeks to provoke discussion upon.

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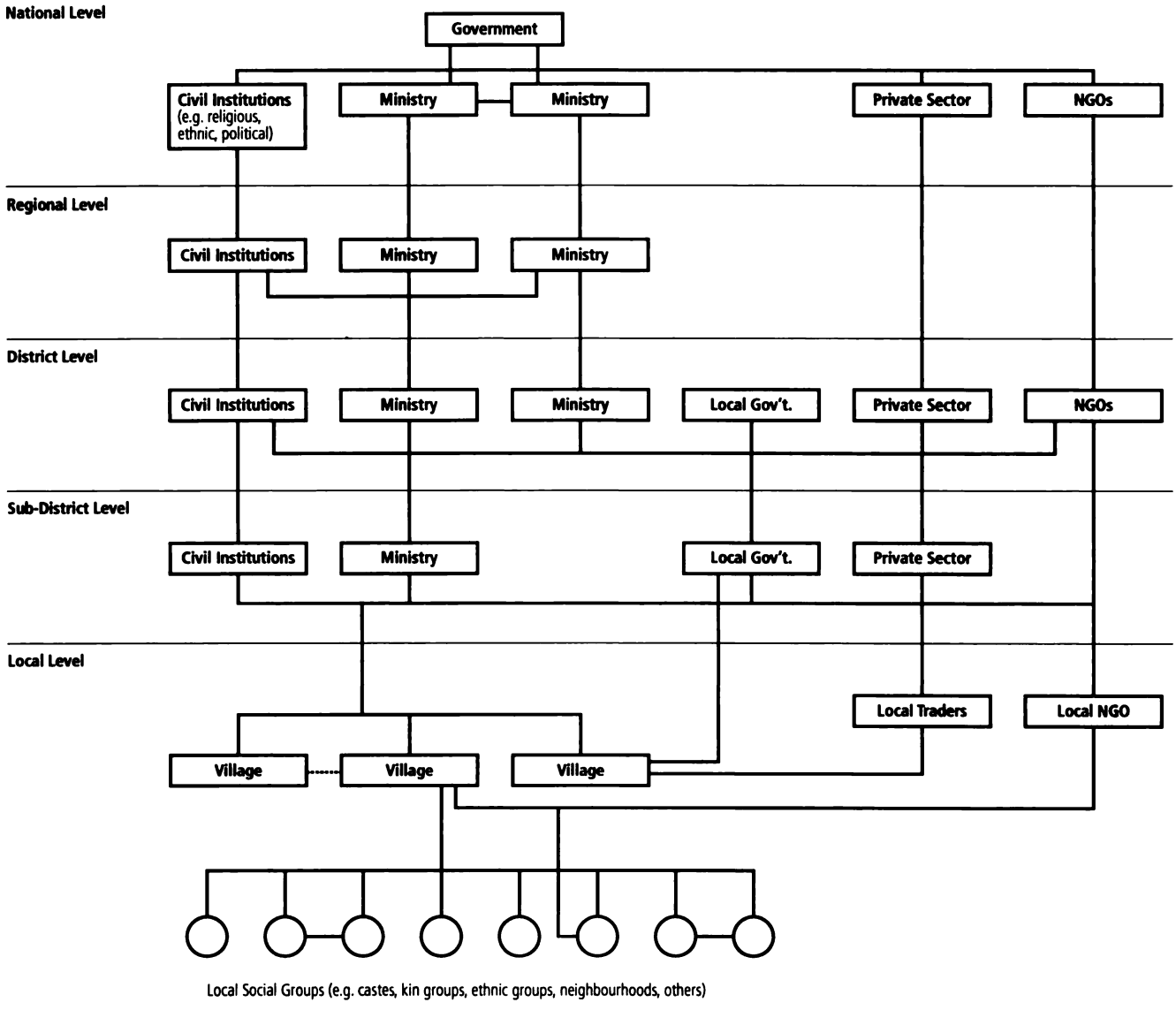
Figure 4 Strengthened Local to National Institutional Relationships
(The development goal, with strengthened horizontal and local-external links and improved government-civil society links)



2.3 Management of Freshwater Resources

The discussion so far has concentrated on the social and institutional dimensions of our concerns. The final part of our conceptual jigsaw is to understand the dynamics and management of freshwater resources. Figure 5 shows the water cycle, the series of stocks and flows through which water moves and that define the relationship between water and ecosystems processes. The basics of this are familiar to us all – water falls as rain or snow, hits the ground and either stays where it is (in ponds or snow fields or as soil moisture), flows over the surface into the river network, or infiltrates down into the water table and sub-surface aquifers. From this initial position it can stay where it is, in a water stock on the surface (lakes, wetlands, etc.) or underground, with the length of time it stays (or the residence time) variable. It can evaporate or be taken up by vegetation, pass through them and enter the atmosphere again (evapotranspiration). Or it can move, following the irresistible pull of gravity to flow over or underground and eventually (sometimes stopping along the way) enter the sea – if it doesn't evaporate or isn't taken up by a plant on the way.

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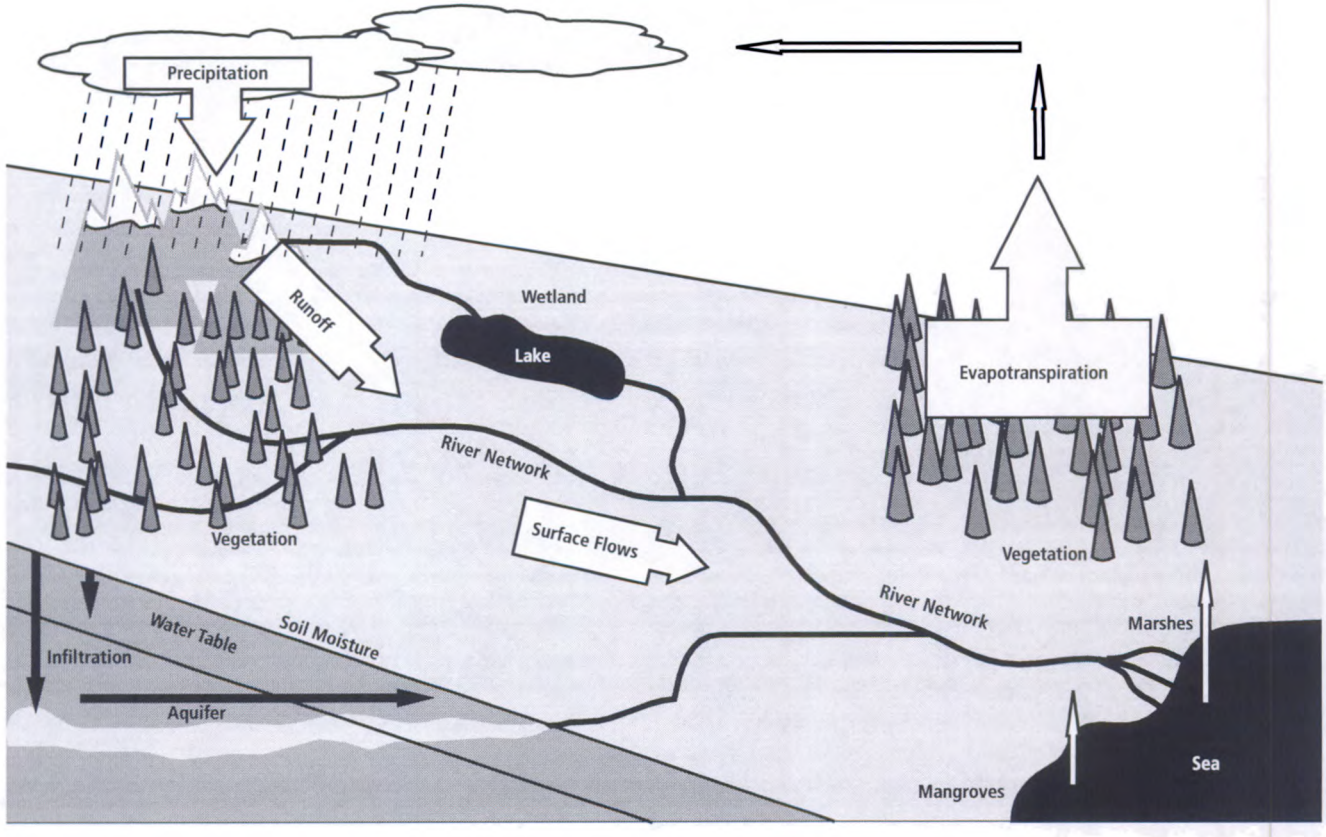
This dynamic process of flows within a system (a catchment or river basin) is central to understanding the nature of water resources and their links to human needs, freshwater ecosystem dynamics and the interrelationships between these ecosystems and social security. Water resources are more than just water as a physical entity. Water resources are best understood as a range of goods and services that are derived from a variety of different points in the water cycle and satisfy a wide range of wants. Of course, water itself is directly abstracted and consumed by people in their homes or used in agriculture or manufacturing. Much of this water re-enters the hydrological cycle, albeit in a different form (sometimes as water vapour) and place (generally downstream), perhaps with changed chemical characteristics (i.e. it is polluted).

Water resources are also other services that water ecosystems and flows provide: for hydropower, transportion, recreation (including the aesthetic value of many freshwater ecosystems) or the disposal of waste products from homes and industry. Finally, freshwater ecosystems are the source of many valued plants and animals that are gathered for sale or home consumption or as inputs into manufacturing. This wide range of functions that freshwater ecosystems support is a crucial part of the story, for different people have different needs and priorities.

In terms of the relationship to social security, however, some are more central than others. In particular, access to adequate and safe water and sanitation can be regarded as the most basic of needs and something that is universal in importance. Where it exists, it is easy to take it for granted, but where it is not available it affects the most vulnerable (the poor, the weak, children, the elderly and women, who also face the burdens of its provision) particularly hard.

There is no simple, direct link between different types of resources and use: in any one place and time different sources of water can be used to meet any one need and, conversely, different needs can be met by any one water source. For example, water for agriculture can come from rainfall, from surface irrigation or from irrigation which taps groundwater reserves. Similarly, a river can provide water for irrigation, drinking water for people and livestock, or act as an input into and source of waste disposal for industry and households. These human uses will inevitably occur in parallel with the ecosystem functions of that river in relation to wetlands it is connected to and the life it contains.

Figure 5 The Water Cycle



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These multiple uses of any water source in an area can be incompatible, both in terms of the amount of water they require and in the effects on the resource they have. And to make life even more complex, the resources themselves move, through the water cycle, so that what happens to water in one place has consequences for all stages in the cycle downstream. For example, using a waterway to dispose of industrial effluents can poison it for drinking, agriculture or recreation downstream, or the diversion of water for irrigated agriculture can undermine the viability of wetland ecosystems. In these and many other ways, using water resources for one purpose affects the other potential uses of those resources.

What is of critical importance is consequently to understand the institutional mechanisms through which different groups gain access to these resources. This is an issue that is really problematic to generalise about, as the nature and functioning of water management institutions is as place-specific as the social structures with which they relate. There are a few general trends that we can identify, but what is more important is that the specific relationship between water management institutions and social security in particular places is seen as a key issue for the development of these institutional processes.

This is not the case in many instances. Water management institutions tend to be centralised, technically-oriented agencies based on one or, at best, two specific aspects of water management. Typical examples of this are water supply utilities (whether state-owned or private sector), whose prime purpose is to control water to supply it to homes and commercial uses and to manage sewage disposal systems. Similarly, irrigation agencies are mostly concerned with the channelling of water to farms, whilst hydropower companies manage water to maximise power generation. These and similar organisations are usually engineering-oriented and centralised in operation. They seek to maximise supply with, in many cases, little regard for the impact of their actions on equity or social security (and too often with a poor understanding of their impacts on ecosystems integrity).

There have been attempts to set up agencies that have a more comprehensive mandate; with, in particular, a lot of faith placed in river basin authorities and planning, such as the Tennessee Valley Authority, the Zambezi Action Plan and the Mekong River Commission. These initiatives are usually mandated to take a more comprehensive approach to the management of catchments, but have rarely been effective in integrating the interests and needs of all parties (and especially the poor) in the approaches they take. They tend to be, yet again, technically-oriented and frequently get bogged down in conflicts over the technicalities of water allocation between constituent parts. This is especially true where more than one country is involved, but is also the case (as in India, Australia and the United States) where different states within a country are included and these states have a constitutional mandate over water resources management.

What none of these institutions do is provide a forum for the type of representative consensus-building identified here as crucial if existing or potential conflicts between different uses of water resources are to be avoided. The characteristics of water resources identified above (and especially their multiple uses and movement within the water cycle) mean that such conflicts are inevitable. These institutions also fail to reflect the potential importance of water supply provision as an 'entry point' for a wider process of social mobilisation, consensus-building and development. As services needed by all and affecting all, water resources development can consequently provide a catalyst for a wider process of development whose significance stretches far beyond the immediate provision of one basic, if essential, service. This means that some new thinking is needed on how to develop effective institutional processes for the management of freshwater ecosystems and how this relates to wider processes of empowerment and development.

An interesting, if as yet unproven, approach being developed by the Centre for Science and Environment in India is the idea of 'River Parliaments': the establishment of a forum in which all interests are represented and which defines the rights and responsibilities of different parties over the management of the river. Although it will be extremely difficult to get such an initiative going, the approach is based upon social rather than technical processes and as such offers the possibility to integrate social security issues and the needs of all interests into the management of water resources. It is these types of approaches, and not traditional 'expert' agencies, that point the way forward.

2.4 Freshwater Resources and Social Security

The global debate on the future of water resources has centred on one concept: scarcity. As we shall see in section 3, this has all too often been taken to be simply a physical scarcity, a lack of water in an absolute sense. But this approach is fundamentally flawed. It reflects neither the dynamics of the resource nor the wide range of different values it possesses. Scarcity should not be seen as a physical absence of water itself, but rather as a shortfall in resource endowments, or the total sustainable value of the different goods and services that water resources (and the ecosystems within which they exist) provide. Similarly, resource degradation is not simply a matter of poor quality; it is a loss of endowments as a result of human use of the resource.

Social security and freshwater ecosystems management are linked and affect each other in a variety of ways (with a wide range of case studies used to illustrate these relationships in other sections of this report). Poor social security systems can have a direct and material impact upon the sustainability of freshwater ecosystems; for example, the lack of clear rights over ecosystems can lead to their rapacious exploitation and degradation (especially where non-local interests are able to access them). Similarly, the degradation of freshwater ecosystems can impact on social security. For example, the overabstraction of water for irrigation, or pollution by industry, can affect the quality and availability of domestic water, with direct implications for health, the burden on women's time, social equity and conflict.

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The dependence that people have on water resources varies greatly, as does their ability to gain secure access to the resources. All of us need some water, for domestic use at a minimum, but many livelihoods (and especially those of the poor) depend on access to water resources. This can be a direct dependence on freshwater ecosystems for groups such as fisherfolk and boatmen. It can be linked to water elsewhere in the water cycle, rain-fed farmers being a classic example. The ability to secure access to these resources both reflects social structures and, for people highly dependent on such access, is a key determinant of their social security.

These problems affect different places and uses differently; they are as varied as water resources themselves. People throughout the world have learned to live with and cope with this variability, often through coping strategies which are risk-minimising and which are highly adapted to the specific characteristics of their area. These coping strategies can and do fail, however, and are in many cases increasingly under pressure from commercialisation and changing patterns of resource use. As such, it is the failure of these coping strategies, which in turn reflects weaknesses in the societal and institutional context in which they exist, not the variable rainfall or river flow, which is the root cause of the problems people face.

This section has presented an outline of a conceptual framework that provides a basis for both identifying the nature of the relationship of freshwater ecosystems management to social security, and understanding what possibilities exist for improving things where this relationship undermines the integrity of the resources or the viability of livelihoods. The approach is, in the next sections, used to analyse the situation the world faces today, consider what the future may hold. and identify what types of strategies can secure enhanced freshwater ecosystems management and improved social security.

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3. Freshwater Ecosystems and Social Security in the Modern World

3.1 Introduction

Water is essential for life and is used for drinking and cleansing (WRI, 1998). It is a key input in agriculture and, unless harvested and artificially applied, is the limiting factor in plant growth in many regions of the world (Agnew and Anderson, 1992). Given an ideal distribution, there is ample freshwater on the planet to support significant growth in the global population. However, as a resource, water often occurs in the wrong place, or at the wrong time and in the wrong quality (McDonald and Kay, 1986). This uneven distribution means that there are many who do not get enough water for their health needs, food production, economic activities and security.

Gleick (1996) has estimated that each person needs a minimum of fifty litres of water a day for drinking, sanitation, food preparation and bathing needs to remain healthy. Gleick (1993) has also estimated that, in 1990, well over one billion people did not have access to this minimum amount needed. Using the United Nations' population projections, Gleick (1993) has gone on to estimate that by 2000, over 2.1 billion people will not have access to the basic need of 50 litres of water a day to be healthy. Even if the lower, more realistic World Health Organisation (WHO) absolute minimum of 20 litres a day is used, many millions of people will not have access to sufficient water of an acceptable quality to satisfy this minimal guideline. As can be seen in Table 1, the largest increase in under-served populations will be in urban areas of developing countries. Nonetheless, the actual number of rural people without access to water by the year 2000 will still outstrip the urban.

Table 1 Developing Country Needs for Urban and Rural Water Supply 1990-2000

	Population not served in 1990 (millions)	Expected population increase 1990-2000 (millions)	Total additional population requiring service by 2000 (millions)
Urban	243	570	813
Rural	989	312	1,301
Total	1,232	882	2,114

Source: Gleick, 1993

Table 2 Sectoral Withdrawals of Water by Region

Region	Sectoral withdrawals (per cent)		
	Domestic	Industrial	Agricultural
Africa	7	5	88
Europe	14	55	31
North America	13	47	49
Central America	6	8	86
South America	18	23	59
Asia	6	9	85
Oceania	64	2	34

Source: WRI, 1998

3.2 Failing Water Management Institutions and the Loss of Social Security

Population growth in developing countries is putting additional pressures on water resources through the need for food production. The drive for increased food production, through 'green revolutions,' has encouraged the rapid development of irrigation systems in many developing countries. The World Resources Institute (WRI, 1986) estimates that the area of land under irrigation worldwide has increased over six times in the last century. Eighty per cent of irrigated land is in developing countries (Heathcote, 1983) and large proportions of many developing countries' water resources are devoted to irrigation: over four-fifths of the annual withdrawal of water resources in Asia, Central America and Africa are used for irrigation (see Table 2). Irrigation, as part of a policy drive towards food self-sufficiency and crops for export, has become the imperative for many developing countries. But this sectoral approach has often eroded the social security of the populations of developing countries. As can be seen from Box 1, the drive to increase cotton production in the five countries in the watershed of the Aral Sea has not only resulted in one of the most profound ecological crises on the planet, it has severely affected the health of the population who once lived on the shores of what was once the fourth largest inland water body in the world.

Irrigation is a thirsty technology. Only half the water supplied to agriculture is available for reuse (Agnew and Anderson, 1992). This compares with 90 per cent from water supplied to industry and homes (Postel, 1986). Over 70 per cent of global water use is devoted to agricultural irrigation. Between 1900 and 1950, global water use doubled and it is estimated that it will double again by 2000 mainly because of population growth and agricultural use (Agnew and Anderson, 1992). At a country-wide scale, this means that several countries in the arid and semi-arid regions are already experiencing a water deficit. Sixteen will have a water deficit by the year 2000, and twenty by 2005 (McCafferey, 1993).

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Box 1

The Health Effects of Irrigation in the Aral Sea Region

The infant mortality rate in Muynak, a fishing town that thirty years ago was on the shore of the Aral Sea, is the highest in the former Soviet Union. In the same period there has been a thirty-fold increase in the rates of chronic bronchitis, typhoid, arthritis and cancer and an alarming rise in the incidence of hepatitis and other liver ailments, throat cancer, kidney failure, gallstones and birth defects. Ninety per cent of women in the town suffer from anaemia. Eighty per cent of the people in the town suffer from some disease or other. Muynak is now 70 kilometres away from the Aral Sea. Huge irrigation projects have been developed to irrigate cotton crops of the steppes of Central Asia. These projects diverted the two major rivers of the region, the Syr Darya and the Amu Drya, and their tributaries into irrigation canals. The water sources that replenished the Aral Sea dried up and, over the last thirty years, this huge water body has halved in surface area.

The population of Muynak has lost its main means of livelihood. In 1957, 3,000 fisherfolk caught 26,000 tonnes of fish a year; in 1994, the remaining fisherfolk harvested just 3,000 tonnes. The associated canning industries have collapsed. Food production has dropped dramatically and the population is dependant on expensive imported foods. Nutritional deficiencies are common and 75 per cent of infants and 80 per cent of toddlers are anaemic. The unregulated use of pesticides, fertilisers, insecticides and even defoliants in the irrigation areas has resulted in contamination of local water resources. The water supplies contain phenols, pesticides, nitrogen compounds and sulphates up to ten times the permissible concentration by USSR standards. The remaining waters of the Aral Sea are heavily contaminated with heavy metals which, through bioaccumulation in fish and vegetables, enter the human food chain. The result, notes Oral Ataniyazova, a gynaecologist and obstetrician working the area, is that "the people are dying like flies."

Source: Agarwal, 1996

Even where extraction of water is only a fraction of the available water resources, the use of water for food production, industrial manufacturing and power generation creates localised scarcities of water. This is particularly true in rapidly urbanising and industrialising areas of developing countries. The focus of planning continues to be on the development of large schemes to harvest and transport water to areas where water is needed for economic and agricultural growth. Often these projects destroy the livelihoods of large populations of invariably poor groups and appear to benefit groups that have the political leverage and economic power to reap the benefits from such schemes. This is the case in western India where the huge Narmada River Project is currently being developed (see Box 2).

Box 2

The Narmada River Project

The Narmada River is the focus of a huge engineering project, the Narmada River Project, which will harness the river's waters for irrigation, hydroelectric generation and domestic water supply. This project includes the building of thirty major dams, 135 medium-sized dams and over 3,000 minor dams over the next 50 years. The largest reservoirs will be the Sardar Sarovar, which it is estimated will stretch for over 200 kilometres behind a 139 meter high dam wall.

This project has been the focus of an international environmental campaign. At the centre of the campaign have been the estimated two million people who will be displaced by the project's activities. Many of these are indigenous tribal peoples or poor peasants. Their future looks bleak. Communities are being dispersed; the formula developed by the Narmada Rivers Tribunal favours large landowners at the expense of smallholders and groups who relied on the forested area that will be flooded. In 1994, the project started flooding the Sardar Sarovar dam area despite many people in the area not having an allocation of land. The flooding was only stopped by the Supreme Court of India.

The beneficiaries of the scheme are the rich landowners from Gujarat. In addition, these landowners and the designers and supporters of the scheme argue that the poor peasantry and shepherds from Gujarat, Suarashtra and Kutch will benefit from the 75,000 kilometres of irrigation systems which are being developed. But Babu (1997) suggests that this is not the case. The peasants and shepherds of North Gujarat are victims of a long policy of misappropriation and mismanagement of water resources in the State. Their benefits will be limited under the Narmada River Project, as well. The real beneficiaries are the landowners who have access to the increased irrigation and opportunities to force forward rapid industrialisation once a ready supply of water is available.

Source: Ruitenbeek and Cartier, 1995

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The Narmada Rivers Project exemplifies an approach of large-scale technical solutions to the collection and redistribution of water which benefits large producers at the expense of smallholders; although a large proportion of water resources in developing countries is used for irrigation, much of this is used by larger farmers in better areas. The large proportion of water withdrawal for irrigation masks the reality that large populations of small farmers in developing countries do not benefit from irrigation schemes. They rely on rain-fed agriculture, and often sophisticated methods of water harvesting and storage. These methods, developed over hundreds and even thousands of years, have sustained populations in arid regions. As can be seen in Box 3, the failure of the government in Tamil Nadu to maintain ancient water tanks has resulted in the breakdown in livelihoods for many of the population.

Box 3

Traditional Water Systems, Failure of Government, Privatisation and the 'Water Lords'

The districts of Pasumpon and Kamrajar are known as 'The Land of Tanks.' Today there are 1,841 tanks, many of which are in disrepair. In ancient times there were as many as 6,000 tanks in the area. For two thousand years the population of this arid district in Tamil Nadu has harvested water for irrigation. David Ludden, who studied these traditional irrigation methods, suggests that in the past "rich peasants dug wells, chiefs built tanks and kings built dams" (quoted in Sainath, 1996: 344). As Sainath (1996) observes, this is a traditional system in crisis. And the people who are most affected are the poor. This ancient system is built in such a way that water draining from one tank is directed, through channels, into a lower tank. Now the system is falling into disrepair. The Public Works Department has only forty per cent of the money it needs to maintain the system and only the most essential of repairs can be carried out.

The result is that water is becoming an increasingly scarce resource in this region. Private entrepreneurs have stepped into the gap to supply water for irrigation. These 'water lords' control water resources in the area. They also own the irrigation pumps which they rent out to less well off farmers. These 'water lords,' who are powerful people, have sunk wells in the beds of ancient tanks. From these, they sell water to the local villagers for drinking and bathing. The local administration can't stop them, as many of the 'water lords' have political connections and even when the collector manages to install a water supply for the poor in the village it is quickly vandalised. Public water supplies damage the 'water lords,' business and profits.

These three cases, the Aral Sea, the Narmada Project and tanks in Tamil Nadu, demonstrate how a failure of institutions to maintain the integrity of the natural resource base and entitlements to water resources results in increased insecurity and impoverishment. The neglect of traditional systems and the focus on large-scale water engineering erodes the social security of populations, often forcing them to become environmental refugees, and destroys freshwater ecosystems.

Often the 'water lords' withhold water from the peasant farmers when it is most needed to irrigate the crops. These farmers are forced into a spiral of poverty, paying for expensive water and losing crops because water has been withheld. Forced into debt, they often lose their land. In this area, the erosion of long-established systems of water management, caused by the inability of state institutions to meet the responsibilities that they have assumed, is undermining the livelihoods of the poor. This means that they lose the few assets they have, and face greater uncertainties and increasing impoverishment.

3.3 Social Security and Sustainable Resource Management

In these and other ways, water is an area of conflict at scales from the global to the household levels. Water resources span international borders, regional and administrative boundaries and are, of course, claimed by different communities and even interest groups within communities. At each of these levels social and institutional networks have been developed to define the rights and entitlements of different groups to water resources, but increasing pressures, changing needs and the erosion of many traditional forms of authority are leading to increasing conflicts over these resources. When these networks do not exist or break down, then conflict can lead to crisis and ultimately war.

The central theme of conflict resolution at all the levels is to increase security and reliability of access to freshwater resources. The identification of the institutions (the national state, regional governments, communities, etc.) which compete for water, and the mechanisms and structures they access, or fail to access, to negotiate for water, provides a framework through which it is possible to evolve a useful model of conflict resolution. Figure 6 considers these issues. At each of the institutional levels there are a number of available approaches to conflict resolution (indicated in Figure 6 by the arrows pointing to the ellipse). The ellipse on the right of the figure details the overall goals of such conflict resolution. The results of the water conflict resolution lead to a series of tangible opportunities. These are indicated by the arrows pointing away from the ellipse towards the level at which they function.

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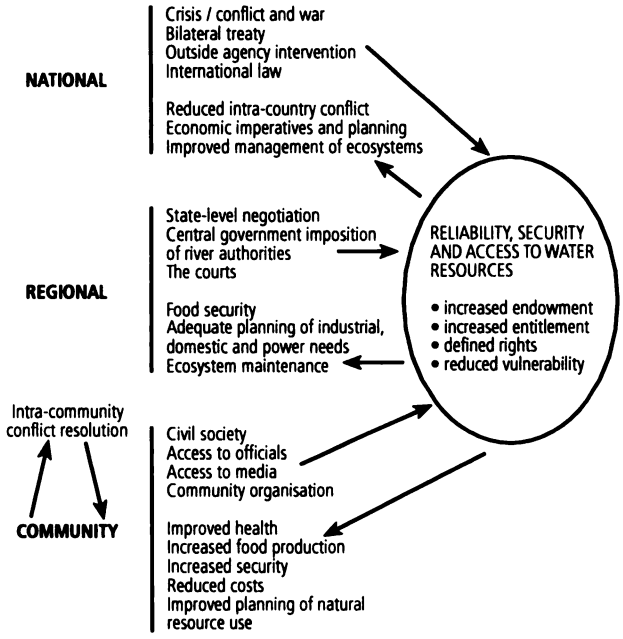
Figure 6 Securing Water Resources at National, Regional and Community Levels: Mechanisms for Resolution and the Benefits of Resolution



3.4 The Challenge: Water Management, Conflict or Cooperation?

3.4.1 The International Level

Water, it is claimed, will be the source of conflicts and war in the next century as oil was in this (Anderson, 1991). Nowhere is this seen more clearly than in the countries of the Eastern Mediterranean. The Grand Anatolia Project in Turkey threatens the flow of the Euphrates in Iraq and Syria. Egypt has frequently asserted that it will go to war with the riparian states of the Nile if they should ever threaten its sole supply of water. Israel has already used its military might to ensure that plans by the Arab Summit of 1964 to develop the headwaters of the Jordan and divert them were abandoned by occupying large areas of these headwaters. The US intelligence services estimate that there are at least ten places in the world (mostly in the Middle East) where war could break out over the shortage of freshwater resources.

However, there are also many examples of cooperation between riparian states in the allocation and control of freshwater resources. The United Nations compiled a list of 3,707 such agreements between riparian states (Wallensteen and Swain, 1996). The conflict between India and Bangladesh exemplifies the problem of overextraction leading to reduced availability of water resource in the lower riparian state. In 1975 a barrage was completed at Farakka, 18 kilometres from the Bangladesh border on the Ganges River. The barrage was built to divert water through a feeder canal to supplement the dry season flow of the Bhagirathi-Hooghly, the river that serves Calcutta and its port and irrigation needs in West Bengal. India diverts 40,000 cusecs of water from the Ganges during the dry season. On occasions this has reduced the flow of the Ganges to a mere 7,000 cusecs (Wallensteen and Stain, 1996), causing damage to the riparian environment in their state, and in particular affecting the world's largest mangrove forest, the Sunderabans. A number of attempts have been made to resolve this dispute, culminating in the signing of the treaty between the two countries in 1997 that defined the mechanisms for sharing the Ganges waters.

The quality of flow is also a significant area of contention between upper and lower riparian states. The Colorado River, shared by the United States and Mexico, has been the subject of an agreement since 1944 when the US guaranteed a minimum flow of 1.5 million acre feet annually to Mexico. During the 1960s the water quality deteriorated because of increasing salinity due to drainage from the Wellton-Mohawk Irrigation Project, causing decreased crop production in Mexico. This led to the US building a desalination plant and agreeing to deliver to Mexico water that would be no more salinated than 300 part per million (ppm). Similarly, polluting with waste salt from potassium mines in the Alsace region was making the Rhine River unusable for agricultural activities and threatening the fish population. A 1975 political agreement between Switzerland, France, Germany and the Netherlands has coordinated water quality data on the Rhine. This action has resulted in a significant improvement in the quality of the entire riparian ecosystem of the Rhine (Wallensteen and Swain, 1996).

Conflict resolution is generally developed without recourse to International Law. Issues of quantity and quality of water resources have been resolved in some, but not all, cases. Indeed, Wallensteen and Swain (1996) suggest that many of the bilateral agreements that have been developed in the past are under threat because of the increasing demands placed upon water resources through growing populations and the need for food security. At present, no international tribunal exists to mediate water-related disputes. Nor is there a consensus amongst international legislators. "What is needed," McCafferey (1993: 93) argues, "is a joint management mechanism, established by agreement, participated in by all riparian states, and perhaps supported by neutral, outside parties, whether states or international organisations."

3.4.2 The National Level

The lack of management mechanisms to resolve conflict in the international arena is reflected within countries as well. Devolution of responsibility for water management and planning to states within countries means that often there is a need for the development of appropriate mechanisms for resolution within countries. The ongoing allocation of rights to water supplies from the Cauvery River between the states of Karnataka and Tamil Nadu in India exemplifies the need for the development of the necessary mechanisms within countries to mediate over water supply. As long ago as 1807, the damming of the Cauvery River in southern India was a source of dispute. The Princely State of Mysore, which controlled the upper reaches of the river, built dams to facilitate irrigation.

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This led to a decline in the flow of water to the rice bowl of Tamil Nadu, then part of the Madras Presidency. In 1829 the King of Mysore made an agreement with the Madras Government to develop no new irrigation projects without the permission of the Madras State.

But the dispute over the release of water into Tamil Nadu from Karnataka has rumbled on throughout this century. Failed attempts at bilateral agreements in the 1970s culminated in the Tamil Nadu Government going to the Supreme Court to demand a settlement. The Court appointed the Cauvery Water Disputes Tribunal, who reported in 1990. This tribunal allocated 205 trillion metres cubed (tmc) of water to Tamil Nadu every year and restricted the expansion of irrigated land in Karnataka. Nonetheless, the supply of water to the rice bowl of Tamil Nadu remains a contentious issue. The new agreement has failed to define when the water will be released and the Tamil Nadu Government is pressing for the development of a schedule of weekly releases to ensure that water is available during the critical summer months to irrigate the kuruvi crop. As M.S. Aiyer, a senior Congress (I) politician has noted, "If no water is available in a specified week in June, there is no purpose in releasing it in September" (Aiyer, 1998: 32). The arguments over the reliability of the release of Cauvery waters rumble on.

This example from India illustrates the points made in section 2 about the characteristics of many national water management institutions, that are typically concerned with one set of issues and that do not effectively represent the interests of all constituencies in their operation. These problems are made worse where, as in India, jurisdictional responsibilities are split between different authorities (in this case states) that have no established platform for collaboration and coordination. The discussion on the nature of institutional development emphasised the importance of integration and collaboration, but this in turn may require some fundamental changes to the structure and mandate of different levels of authority within a nation.

3.4.3 Local Level Urban

The world is becoming an increasingly urban place, with the majority of the population of the developed world and of Latin America already urban dwellers, and the cities of Africa and Asia growing rapidly. In most cases, these communities are not directly involved in the management of freshwater ecosystems, but they do need access to the services that these resources provide. For these people, a major concern is consequently the character and effectiveness of the intervening agencies through which these resources are provided.

A key issue at a local level is the negotiation of water supply needs between communities and service providers and within communities. In the slums of Bombay, for instance, there is a relationship between the ability of slum dwellers to organise around the issue of water provision and to negotiate with service providers, and the quality, reliability and cost of water provision in the slums. A recent survey in thirty-three slums in the suburbs of Bombay (Emmel, 1998) established that in slums which have developed effective local organisations, water supplies are adequate, while in slums with no organisation, water is controlled by private landlords, supplies are unreliable and the water is expensive.

In the first group of slums, ensuring a regular supply of water supply has involved the building and maintenance of local water networks. This building work has involved considerable cooperation between households in the slum and the development of organisational structures to develop and maintain the water system. These organisations must continuously negotiate with the municipal service provider, the Brihanmumbai Municipal Corporation (BMC), to maintain the slum's water connection. The continued supply of water to the slum by the BMC is ensured through regular payments collected by these organisations within the slum to cover water bills, and through a recognition by the service providers that they enjoy the popular support of the residents of the slum.

Access to adequate and reliable water is reflected in the health of the slum dwellers. In the adequately-served slums, the slum dwellers report a lower perceived incidence of diarrhoea than in the under-serviced slums. It is also reflected in the nutritional status of the slum dwellers. In the adequately-served slums, none of the children between the ages of one and five years were malnourished, while in the under-served slums, over 75 per cent of the children were either moderately or severely malnourished. Although many other factors confound a direct correlation between water supply and the nutritional and disease status of the children, in this survey it is apparent that the development of appropriate organisation with which to develop and negotiate with service providers for water is an important aspect of maintaining livelihoods in the slums of Bombay.

3.4.4 Local Level Rural

Social organisation to access and manage water resources is also an important feature of rural life in many parts of the world. Machakos District, situated in south-east Kenya, is considered by many to be an example of what rural development can achieve. With funds provided by the Swedish International Development Agency, the Kenyan Government started projects with traditional local organisations in 1979. These local organisations, called mwethya groups, comprise mainly women. They practice a terracing method known as fanya-juu. This involves ditch digging along the contours of hills. The soil from the ditch is thrown up the hill to form a bench terrace. The value of this method of terracing is that it maximises erosion control while ensuring rainwater control. Since 1979, over 1000 kilometres of terrace have been developed by the mwthya groups; 70 per cent of the cropland in

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Box 4

The Response by Local Institutions to Drought in Burkina Faso

The Mossi plateau in Burkina Faso forms a band across the country and receives approximately 700 mm of rainfall per annum, varying significantly in extent, duration and intensity. A typical rainy season lasts for about 120 days, with intermittent rains from May onwards, giving way to short but heavy rainstorms in July and August. Since 1976 rainfall levels have been falling, compared to a sixty-year running mean. In Yatenga province in the Mossi plateau, the normal yearly rainfall is around 735 mm, but from 1970 to 1980 it fell to 575 mm, and further still to 491 mm in the period 1980 to 1988. This period was known by the local Mossi ethnic group as the '16 year' drought. This drought period led to migration south, food shortages, land degradation and largely ineffectual efforts by the international development community to mitigate these problems.

In response to water shortages and the impact that had on food production and agriculture, a number of traditional initiatives were called upon by local communities. The relationship between agricultural production, water conservation and environmental degradation was mediated in the past by local institutions based on mutual cooperation and self-help at the level of the village. The most famous of these arrangements was known as the Naam movement, which is an egalitarian age-set organisation that promoted group activity, solidarity and reciprocal aid amongst the membership of the group. There are different Naam groups, depending on age, group and sex, and most work independently, although they come together for labour-intensive activities such as harvesting.

The Naam movement is famous for developing diguettes, or stone lines, in the drought period, as a response to water shortages. Diguettes are constructed along contour lines with local stones and are designed to temporarily restrict the water movement across fields, increasing infiltration time and also catching organic debris. The lines are often reinforced with vetiver grass or with agroforestry trees. The lines are extremely effective at increasing agricultural production, reducing soil erosion, reclaiming degraded fields and replenishing aquifers. The incidence of stone lines in the drought periods significantly increased throughout the Mossi plateau. The lines were spontaneously disseminated through traditional arrangements, such as Naam, and led to a widespread increase in food and water security. In addition to the diguettes, other water harvesting technologies were also spread via the traditional institutions, such as: Zai, which are small pits dug in the field with a little compost to trap water; demi-lunes, or half-moons which were constructed out of earth on the downside of the contour, again used to trap water; erosion bunds, again dug on contours, with a depth of about half a metre to increase water availability for crops; and grass lines. These technologies were largely developed from existing local expertise and distributed through traditional institutions. The functioning of these groups and their networks were recalled during a period of water shortage to ensure local livelihoods and social reproduction.

Source: Howorth, 1999

the area is now terraced. Postel (1992) estimates that corn yields on these terraces have increased by over 50 per cent. Critchley (quoted in Postel, 1992: 118) suggests that "the existence of well developed self-help groups is one of the main reasons for the success of conservation activities in Machakos."

Such social structures are important in the normal rhythm of life, but can be of critical importance in times of real jeopardy, when extreme environmental events (or human artefacts like markets or wars) threaten their very existence. The role of social organisation in preserving the collective good and conserving fragile resources is particularly important in areas such as the Sahel region in Africa, where high levels of environmental hazard or variability are the norm. Box 4 illustrates such a case for Burkina Faso, but many comparable examples are found around the world. They illustrate the importance of social relations in the present and future maintenance of the integrity of freshwater ecosystems.

These traditional management systems can, however, come under threat as wider economic and political changes penetrate rural areas. Box 5 presents such a case from Zimbabwe, where the erosion of traditional access rights to wetland areas is threatening both the access of some sections of the population (especially women) to water and the viability of these wetland areas. These types of trends are found in many parts of the world, and illustrate the importance of understanding the dynamics of change in all aspects of social relations to water resources. It is these dynamics that have the potential to undermine both social security and freshwater ecosystems, but that are also the context within which sustainable management opportunities must be understood.

The influence of external institutions need not be negative, however, for they often possess great potential to be the catalyst for the emergence of more robust social relations and more sustainable resource management approaches that both meet people's needs and conserve the resource base even in the face of, as in the example in Box 6, the most extreme forms of external threat (in this case from Hurricane Mitch, which devastated large tracts of Central America). This is the challenge: to identify and build on these examples of good these models of best-practice to ensure that the approach to freshwater resources management is one that reduces the vulnerability of both social institutions and freshwater ecosystems to negative impacts from external forces.

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Box 5 Zimbabwe

Economic Liberalism, Conflict and the Maintenance of Dambos in Zimbabwe

The state in Zimbabwe is the ultimate custodian of natural resources and development projects in communal and resettlement areas, including irrigation schemes and control over the dambos (dambos are areas of wetland found in valley bottoms or along stream banks and are used for small-scale irrigation in its broadest sense, i.e. watering gardens, grazing cattle and household water supply). However, much of the control of these resources is passed on to the community, and once a community is given a piece of land with an irrigation scheme, the individuals who use that land have complete control. In many of these irrigation schemes there is evidence of rule-breaking against official management principles in spite of the state having localised the control system. These involve selling pieces of land, illegal renting and expansion of plots, which is also rife in the dambos. Market liberalisation in Zimbabwe has unleashed various kinds of organisations that seek to align themselves with the rural producers. These new sets of entrepreneurs have become noticeable in the rural landscape since 1990. They have started to exploit the rural market and production system that for a long time has remained marginalised because of the general conception that smallholder farming was inefficient. Many people are beginning to realise the efficiency of smallholder production systems as low input and high output. Thus, new relations are developing between the smallholder and private buyers and, since 1990, private companies have started to play an active part in contract farming. Evidence exists to show that without secure title to land, many farmers in communal areas are engaging in contract farming to produce horticultural crops. The smallholder is thus contributing to the development of a land market, as the value of dambos and irrigation schemes as sources of capital accumulation are increasing.

The high potential special resource niches in communal areas in the form of wetlands/dambos, and irrigation schemes in resettlement areas present the greatest opportunity for intensive land use and socio-economic reproduction. The fact that land with dependable water supply is limited in the rural areas means that some households use these resource niches for political and economic opportunities which leads to greater conflict over these resources. In this battle, it is women who are the losers and it is the household food supply and household nutrition that ultimately suffers.

These trends are worrying and they are testing the ability of social formations to control and mitigate these processes. Even more worrying is the emergence of new entrepreneurs with connections to the state. In the case of Tanzania (Cachage 1993), liberalisation replaced mercantilist forms of accumulation with parasitic forms based on plunder, which contributed to deep popular resentment and cynicism with regard to liberalisation.

Source: Matondi, 1998

Box 6 Honduras

Hurricane Mitch and Sustainable Farming in Honduras

The storm that devastated much of Honduras and northern Nicaragua went directly over the remote Honduran village of Guarita near the El Salvador border. There is, however, little evidence of the hurricane passing. Much of the population is of Lenca Indian origin, and illiteracy is at about 50 per cent. However, while much of the country was devastated by Hurricane Mitch, no one died in the south of Lempira and the damage was minimal. The explanation is an indigenous system for farming mountainsides that is being supported by the Honduran government and the UN Food and Agriculture Organisation (FAO). The system is so successful that those using it only lost 10 per cent of their crop after the 1997 drought and, even after the hurricane, farmers had a grain surplus. The Quezungal method is a stick and plant method that avoids the slash-and-burn technique that removes vegetation cover and damages watersheds.

Almost 70 per cent of Honduran farmland is located on hillsides, but the agricultural colleges have traditionally taught plains farming techniques in the interests of the agribusiness companies that dominate the export trade. The destruction of Hurricane Mitch was a direct consequence of this one-sided approach to agricultural development. When Hurricane Mitch resulted in a record volume of water falling over the Honduran mountains, the lack of hillside vegetation led to rapid run-off, and the eroded soil and loose rocks caused devastation to humans, livestock and farms. Lack of planning also exacerbated the loss of life from the floodwaters.

The Prolesur project (El Proyecto Lempira Sur), implemented by the FAO and the Honduran government, works with 84 communities in the south of the province of Lempira. Those farmers who slash-and-burn have now been reduced to single figures, and the project works with local farmers to promote the Quezungal method of farming. This method involves planting crops under trees, whose roots anchor the soil. Vegetation from pruning provides the soil nutrients and water retention, and terracing reduces erosion. This FAO/Honduran project is now classed by the World Bank as a model of good practice in sustainable farming and soil and water conservation. It is clear that by supporting local techniques and institutions, local com-

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3.5 The Role of Ecosystems in Social Security Provision

At all three levels, national, regional and community-the common theme is that fair and sustainable access to water is defined by the ability to develop appropriate institutions to allocate these resources and to meet stakeholders' perceived needs. Often this process has to contend with competing interests and agendas. Such an investigation raises questions about reliability and security of access to water resources. As will be noted from the case studies presented above, these issues need to address access to water – by countries, regions, communities and households – to produce adequate food, continue their economic activities and remain healthy. The discussion must also address the viability of the uses that water is put to. Human activity can degrade ecosystems that are reliant on water, through changing the quality and quantity of water available to the ecosystem. Overexploitation, either directly or indirectly, imperils the sustainability of ecosystems which are vital for the Earth's health, and threatens the social security of this and future generations.

The World Resources Institute (WRI, 1998) suggests that the real value of ecosystem services is about twice that of global gross national product, or about US$ 33 trillion. The authors point out that human life is impossible without the ecosystem services outlined in Table 3. Nonetheless, the incorporation of ecosystem services into the decision-making and planning is still rare. Only when degradation impinges directly on human activities is the importance of its value truly appreciated. Often this is valued in the costs incurred in the rehabilitation of ecosystems or in providing alternatives, not the inherent values of the ecosystem itself.

Table 3 Ecosystem Services: Free but Valuable

Ecosystem Service	Value (US$ trillion)
Soil formation	17.1
Recreation	3.0
Nutrient cycling	2.3
Water regulation and supply	2.3
Climate regulation (temperature and precipitation)	1.8
Habitat	1.4
Flood and storm protection	1.1
Food and raw materials production	0.8
Genetic resources	0.8
Atmospheric gas balance	0.7
Pollination	0.4
All other services	1.6
Total value of ecosystem services	33.3

Source: WRI, 1998

As was noted in the discussion of the polluting effects of the Wellton-Mohawk Irrigation Project on the Colorado River water uses can have a profound effect on livelihoods and ecosystems. Nowhere is this seen more clearly than in the case of the Aral Sea, presented in Box1. In both cases, the rehabilitation of these freshwater ecosystems is very expensive. On the Colorado River this has involved the building of a desalination plant to ensure that the river's water quality is adequate for other human uses downstream in Mexico. Similarly, the rehabilitation projects initiated in Alsace on the Rhine, to reduce salt inputs from potassium mines, has cost an estimated 100 million French Francs (Wallensteen and Swain, 1996). A huge rehabilitation scheme is now underway in the five riparian states of the Aral Sea and its water sources, funded by the World Bank, the United Development Programme (UNDP), the United Nations Environment Programme (UNEP), and the Global Environment Facility. US$ 40 million has been spent in the preparatory phase alone, and a further US$ 260 million is already committed for restoration work in the first phase of the project (Agarwal, 1996).

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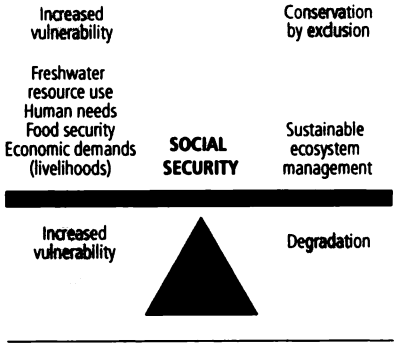
Figure 7 The Balance between Freshwater Resource Use and Ecosystem Maintenance



It may be inferred, therefore, that any human activity to use freshwater resources will inevitably degrade the quality of freshwater ecosystems. Certainly from the examples presented above this would appear to be the case. Economic imperatives, combined with demographic trends and the need for increased food production and security, appear to lead to freshwater ecosystem degradation (the more so given that these ecosystems are rarely valued in economic terms). But this need not be the case. The Mahakali Treaty (Jha, 1996) was explicitly developed to address issues of river ecosystem maintenance in Uttar Pradesh, as well as addressing the economic needs of the two states linked in one river basin.

The challenge is to develop strategies that account for both the maintenance of freshwater ecosystems and address needs for their use. Figure 7 represents the complexity of this debate. This is a balancing act in which, as has been shown in several of the examples above, the degradation of ecosystems leads to increased vulnerability. Nonetheless, freshwater ecosystems must be exploited. In a world where, as was pointed out at the start of this discussion, over two million people do not have access to sufficient water to be healthy at the turn of the millennium (Gleick, 1993), strategies of ecosystem conservation that exclude people from them to maintain their pristine condition do not offer a feasible alternative. This, too, will increase the vulnerability of populations, and is unlikely to be effective in maintaining the ecosystems as encroachment inevitably occurs.

It is apparent that innovative methods will have to be sought to develop a balance between the freshwater resource use inherent in a livelihoods approach, and ecosystem maintenance. The experience of New York City in managing its water resources points to the challenges that face water resource planners. Recent investment in the purchase and management of land in its water catchment has saved New York City the expense of installing expensive treatment plants to purify water for the city. Aside from saving an estimated US$ 6.5 billion, the management of these upland resources has created new wildlife habitats, other ecological resources and provided areas for recreation (WRI, 1998). This experience points to the need for the sustainable management of resources while still addressing human needs for freshwater resources.

The balance between the two imperatives of freshwater resource management is the challenge that faces us as we enter the 21st Century. As has been dealt with in some detail, there are a large number of institutions, ranging from the international to the community level, which negotiate for freshwater resource use to maintain livelihoods and increase social security. Within these forums there is also a need to address sustainable management practices of freshwater resources. It is to these issues that the discussion now turns in an investigation of the global scenarios for freshwater management in the 21st Century.

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4. Possible Future Scenarios and Social Security

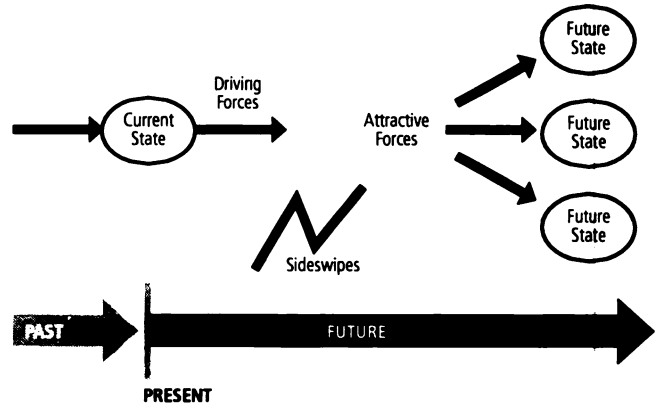
4.1 Introduction

Scenario generation is an important tool for long-term planning and policy formulation. Scenario generation involves creating a narrative, using socio-economic and environmental data, to indicate a possible future. The creation of different water scenarios combines many interacting elements, including: hydrology and climate, population growth and demographic patterns, economic scale and structure, technology and efficiency, policies and institutions, lifestyles and values (Raskin et al., 1995). These water scenarios help policy makers and managers understand how the world might change, recognise when it is changing and, if it does change, know what to do (Schwartz, 1991).

The data sets behind these scenarios are often incomplete and do not contain sufficient details to accurately predict future outcomes. However, the objective is not to accurately predict (past water predictions have shown the difficulty in doing this, see Shiklomanov (1996: 82) for a discussion of this issue) but to create a vision which is aimed at directing future water policy. Therefore, this is a visionary process, one aimed at looking into the future and asking: What implications does this development trajectory have for global, regional and local water use? If this is not satisfactory or sustainable, a different vision can be created and, in doing this, planners and policy makers can make decisions on how to alter conditions to arrive at the chosen 'vision.' All these scenarios or visions have their basis in current water withdrawal and consumption rates, and use today's data as their starting point.

The current socio-economic and environmental situation is dominated by factors of influence known as driving forces (see Figure 8); it is these forces that will determine the direction of our water future. Driving forces include prevailing economic approaches, human values and beliefs, scientific paradigms, environmental change and political systems. At this point, the scenario is developed using the current driving forces. The scenario narrative is told through the evolution and development of these driving forces.

Figure 8 Driving Forces, Attractors and Sideswipes



Source: Raskin et al., 1997

Within the scenario there are also attractive and repulsive forces. Attractive forces are those that suggest possible futures are in line with sustainability principles, such as consumption limits and resource use. Repulsive forces suggest non-sustainable futures and thus are not followed. Finally, sideswipes, are those unknown and unpredicted influences that may arise during the development path, e.g. a world war or global epidemic. These driving forces may take us three ways: to the conventional water world (CWW), to a world where there is a water crisis (WC) or to a sustainable water world (SWW).

4.1.1 A Note on Methodology

Projecting future water use has been a preoccupation of scientists for many years. Depending on the overriding scientific and social climate at the time of making these projections (for example, population explosion, acid rain, depletion of fossil fuels or climate change), there have been different levels of assessment. Table 4 shows the range and variation in these assessments.

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Table 4 Global Water Projections

Study	World Withdrawal (km³)	Year
Nikitopoulos (1967)	6,730	2000
L'vovich (1974)	7,000	2000
Falkenmark and Lindh (1974)	8,380	2000
Falkenmark and Lindh (1976)	3,986/4,961	2000/2015
De Mare (1976)	6,080	2000
WRI (1990)	4,195/4,350	2000
Shiklomanov (1993)	5,190	2000
Shiklomanov (1996)*	3,940	2000
SEI (1997)	5,000	2000

*Source: Raskin et al., 1997; * Shiklomanov, 1996*

Currently, it is widely accepted that the assessments made by SEI (1997) and by Shiklomanov (1997) are the most accurate. However, even the latter has built upon his mistaken predictions to come up with the most recent shown in Table 4. The assessments made by Shiklomanov in 1987 for the period 1990 to 2000 greatly overestimated global water withdrawal and consumption (except in North America) because he overestimated the growth in irrigated lands and the growth in withdrawal for industry. The growth rate appeared to be not so high in the majority of countries as it had been assumed.

There is a general pattern that assessments are falling, peaking at 8,380 km³ in 1974 and falling to 3,940 km³ in 1997. This reduction may be due, in part, to the realisation by scientists of the capacity of humans to respond to water shortages (or threats of water shortages) through the development of new technologies or changes in consumption patterns (e.g. from water recycling to improvements in irrigation technologies). Also, as threats such as acid rain are dealt with by the international community, the projections will alter accordingly.

Therefore, assessing future water use is a dynamic process and will change depending on the overriding social concerns and the level of available technology. An additional problem which relates specifically to the CWW is that this development trajectory will, by implication, alter its own course. The CWW is likely to be knocked off course by the stresses it will impose on environmental resource and institutional systems, and by future surprises that are incompatible with the assumption of evolutionary continuity in socio-economic systems (Raskin et al., 1995).

However, the responses to these stresses are also not known, so it has to be assumed that the former will guide the CWW back on its assumed trajectory. As long as the scenario process is not considered to be scientifically rigorous, it can help developed and developing countries make plans for the future.

There are differences in how the following three scenarios are presented. The CWW is presented with statistics, which are based on current water withdrawal and consumption rates. The CWW also uses current socio-economic and political structures as a basis with which to predict future arrangements. The other two scenarios can be classified as 'visions,' as they are presented as narratives and are based largely on 'what ifs.'

4.2 The Conventional Water World

The CWW builds up a picture of water use and availability from the assumption of continuing current trends. There is an assumption that demographic, socio-economic and technological patterns gradually evolve without significant surprises, radical technological innovations or fundamental policy changes (Raskin et al., 1997). The CWW assumes the dominance and evolution of the current development paradigm that encapsulates globalisation, free trade, private investment, unregulated markets, competition, mid-range population growth, urbanisation, industrialisation of the periphery, and governance based on the nation-state model. The guiding principles of the CWW are evolution, convergence and integration (ibid, 1997).

In the CWW, global economic patterns persist and there is a continuing concentration of wealth in the industrialised countries (see Table 5).

The industrialised nations have considerably smaller populations than the developing economies, and this pattern continues with significantly higher growth rates in the latter (see Table 6).

Table 5 GDP Projections (US$ billion 1990)

Region	1990	2025	2050
North America	6,040	14,884	21,063
Western Europe	7,171	15,917	23,660
OECD Pacific	3,524	8,100	11,748
Former USSR	854	1,898	2,756
Eastern Europe	210	467	679
Africa	401	1,657	4,245
South America	994	3,018	6,038
Middle East	541	2,237	5,071
China	451	2,698	6,391
South and East Asia	1,043	4,943	12,631
World	21,230	55,820	94,282
Industrial	16,735	38,901	56,471
Transitional	1,065	2,366	3,435
Developing	3,430	14,553	34,376

Source: Raskin et al., 1997

Table 6 Population Projections (millions)

Region	1990	2025	2050
North America	277	330	322
Western Europe	456	489	477
OECD Pacific	145	161	157
Former USSR	289	332	349
Eastern Europe	100	115	121
Africa	640	1,519	2,204
South America	445	699	812
Middle East	151	384	557
China	1,223	1,733	1,867
South and East Asia	1,564	2,634	3,214
World	5,290	8,395	10,080
Industrial	878	980	956
Transitional	389	447	470
Developing	4,023	6,968	8,654

Source: Raskin et al., 1997

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Table 7 Dynamics of Water Use by Continent (km³/year)

Continent	Assessment								Forecast		
	1900	1940	1950	1960	1970	1980	1990	1995	2000	2010	2025
Europe											
Withdrawal	37.5	71	93.8	185	294	445	491	512	534	578	619
Consumption	17.6	29.8	38.4	53.9	81.8	158	183	187	191	202	217
North America											
Withdrawal	69.4	222	286	411	556	663	642	679	718	780	836
Consumption	29.3	83.8	107	145	183	224	225	247	269	304	329
Africa											
Withdrawal	41	49	56	86	116	168	199	215	230	270	331
Consumption	34	39	45	66	88	129	151	160	169	190	216
Asia											
Withdrawal	4,143	689	859	1,222	1,499	1,784	2,067	2,334	2,245	2,483	3,104
Consumption	22	528	654	932	1,116	1,324	1,529	1,566	1,603	1,721	1,971
South America											
Withdrawal	15.2	27.7	59.4	63.6	85.2	111	152	166	180	213	257
Consumption	11.3	20.6	44.7	44.4	57.8	70.9	91.4	96.9	103	112	123
Australia and Oceania											
Withdrawal	1.6	6.8	10.3	17.4	23.3	29.4	28.5	30.5	32.6	35.6	39.6
Consumption	0.6	3.4	5.1	9	11.9	14.6	16.4	17.7	18.9	21	23.1
Total (rounded)											
Withdrawal	579	1,066	1,365	1,985	2,574	3,200	3,580	3,760	3,940	4,360	5,187
Consumption	415	705	894	1,250	1,539	1,921	2,196	2,275	2,354	2,550	2,879

Source: Shiklomanov, 1996

Table 8 GDP and Water Intensity by Region in 2025

Region	GDP (US$ trillion 1990)	Water intensity (litres/$)
North America	14,892	41.5
Western Europe	15,916	19.8
OECD Pacific	8,099	17.2
Former USSR	1,896	258.7
Eastern Europe	468	177.4
Africa	1,657	153.8
South America	3,016	122.5
Middle East	2,240	142.5
China	2,698	290.7
South and East Asia	4,944	330.7
World	55,826	89.7

Source: Adapted from Raskin et al., 1997

This means that globally, much of the economic wealth is concentrated in a relatively small proportion of the global population, that is in the industrialised countries. It is in the countries of Europe and North America that water withdrawals are highest (with the exception of Asia, which has by far the highest projected withdrawal rates as a result of irrigated agriculture and absolute water abundance and good access) (see Table 7).

It is also in the industrialised countries where water will have the highest associated costs (see Table 8).

The ability of industrialised countries to recover costs will have high implications for water sustainability. The associated politico-legal structures in these regions will make this exercise easier. In the developing countries, however, water is considerably cheaper (in relative terms), although access to water and water of quality is problematic (access and quality are not problems in industrialised countries). A particularly important trend in the CWW is the rapidly urbanising global population, especially in developing countries (see Table 9).

In industrialised nations, there will not be a significant increase in the numbers of people living in towns and cities and, consequently, there will be minimal strain put on urban systems. Access to domestic water in these areas will be almost guaranteed although, as Table 8 shows, costs will be high. This ensures a vital ingredient for social reproduction in these areas. In developing countries, however, the growing urban population above the planning capacity of these areas will have serious implications for social security. Much of the urban growth will be in unplanned settlements with little or no access to safe water supplies or adequate sanitation. This will result in the significant increase in the number of vulnerable people in urban situations in developing countries, with a risk of an increased incidence of water-borne epidemics.

Water use, by sector, will be dominated by agriculture, particularly irrigated agriculture, although rain-fed agriculture will experience something of a renaissance (see Table 10). This will be due to a general saturation of productivity levels with irrigated agriculture (particularly in Asia), and an increased reliance on rain-fed agriculture as large sectors of the population in developing countries cannot afford to participate in irrigation schemes.

Industrial water use will also see an increase, almost doubling by 2025. Much of this growth will be in the developing countries, as the water-intensive technologies as a means of production, which are owned by transnational corporations, are "exported." Industrial water use in developing countries will begin to slow down as the 'dematerialization' of production begins. This pattern will increase the low-grade employment opportunities in developing countries and it will mean that more available water resources will be diverted to water-intensive industries. This often threatens access to water during spells of drought.

The institutions governing water use are increasingly located in the private sector. This is particularly true in the developed economies where water extraction, supply and maintenance are all in the hands of the private sector, with government providing a regulatory role. This limits the influence of civil society on water use and supply, and the relationship is reduced to supply-and-demand economic rationale. In developing countries, the private sector plays an increasing role in the provision of water infrastructure because national governments are increasingly experiencing public sector spending deficits. In cases where governments retain control, the emphasis is on low-cost, decentralised, local institutional water management. The process both empowers local communities and reduces their access to water resources as private, economically-motivated enterprises dominate the control of water.

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Table 9 Urban Population, 1950 – 2020 (%)

Geographical Region	1950	1960	1970	1980	1990	2000	2010	2020
World	29	34	37	40	45	51	57	62
Developed Countries	54	61	67	70	73	75	78	81
Less Developed Countries	17	22	25	29	37	45	52	58
Africa	15	18	23	28	34	41	47	54
South America	42	49	57	65	72	76	80	83
North America	64	70	74	74	75	77	80	83
Asia	16	22	23	26	34	43	50	56
Europe	57	61	67	70	73	77	80	83
Oceania	61	66	71	71	71	71	73	76

Source: United Nations, 1991

Table 10 Dynamics of Water Use According to the Activity (km³/year)

Sector	Assessment								Forecast		
	1900	1940	1950	1960	1970	1980	1990	1995	2000	2010	2025
Irrigated land	47.3	75.9	101	142	173	200	243	254	264	288	329
Agriculture											
Withdrawal	525	891	1,124	1,541	1,850	2,191	2,412	2,503	2,595	2,792	3,162
Consumption	407	678	856	1,183	1,405	1,698	1,907	1,952	1,996	2,133	2,377
Industry											
Withdrawal	37.9	127	182	334	548	683	681	715	748	863	1,106
Consumption	2.96	9.49	14.4	24.6	38.3	61.8	72.7	79.7	86.7	111	146
Municipal											
Withdrawal	16	36.8	52.6	82.7	130	208	321	354	386	464	645
Consumption	3.87	9.04	13.8	20.1	29.4	41.9	53.2	57.4	61.6	68.1	80.9
Reservoirs	0.3	3.7	6.47	22.7	65.9	119	164	188	211	239	275
Total (rounded)											
Withdrawal	579	1,066	1,365	1,985	2,574	3,200	3,580	3,760	3,940	4,360	5,187
Consumption	415	705	894	1,250	1,539	1,921	2,196	2,275	2,354	2,550	2,879

Source: Shiklomanov, 1996

Economic processes within developing countries begin to echo global economic patterns, with an increasing polarisation of wealth and access to resources within countries. This is not echoed in national economic indicators, but is seen in poverty indicators. These patterns seem to refute the arguments of those scientists involved in the water predictions, who used population growth as the critical variable in their calculations. The increasing concentration of wealth among the growing elite within countries means that a smaller number of people are increasingly using more water and large, growing populations are surviving on less water per capita than previously. This pattern can particularly be seen in urban situations where low-density, well-kept, water-intensive households back onto high-density, unplanned settlements with no access to safe water. This, accompanied by the globalising, neo-liberal economic climate, means that the private sector is dominating water extractions which are being used to export both food and industrial products.

This general process results in a growing number of vulnerable people. It is therefore clear that population alone should not have been used as the major variable rather, it is the economically-empowered population that has had most impact on water withdrawal and consumption. In this respect, developed countries will have much higher levels of social security in relation to freshwater than developing countries. In a similar fashion, the wealthy sectors of developing countries will also have more social security than the poorer sectors (and non-urban) – this also relates to water quality. It is therefore necessary to highlight that, regardless of the availability of physical assets, it is the access to these assets which is important and much of that access depends upon income levels. Thus, the 'polarisation of wealth' debate indicates a move towards the smaller, more privileged sectors of society, having more social security than the larger, underprivileged sectors at both global and regional levels.

4.3 Water Crisis

The water crisis scenario originates from the CWW vision which continues up until 2015 without deviation from its original path. However, in this scenario, global economic growth does not increase to the extent where convergence of income levels begins. There is more unequal competition for global resources, wich results in increasing polarity of wealth and the 'haves' living in a world that resembles a rich ghetto in an increasingly barbarous planet. The slower growth of the WC scenario results in a number of nations, particularly those that are already economically disadvantaged, experiencing a fall in standards of living. This increases the number of people living in relative and absolute poverty. The result is widespread environmental degradation, as people are forced to make do with even more marginal resources, vulnerability increases to epidemic proportions, and migration to the more wealthy areas is often the only option.

Water abstractions slightly increase from the level of the CWW, but there are no concurrent developments in efficiency or a change of consumer patterns. The investment in water infrastructure increases slowly, in line with the general rate of economic growth. Economic expansion is causing serious stress on natural resources and on human systems, resulting in significant ecosystem breakdown and the disappearance of traditional management institutions as people are marginalised.

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The general trend in the WC scenario is one of increasing water shortages, which increase conflicts and restrict development and growth in most regions. Some regions, however, such as the Scandinavian countries and Canada, experience no water problems as they are geographically fortunate to be located in areas of water abundance. As the date progresses towards 2050, the planet is increasingly made up of closed economies which must protect their borders from environmental and economic migrants.

Most global economies are now extremely vulnerable and cannot withstand environmental shocks such as hurricanes and droughts, which cause economic collapse in some countries when they take place. Investment in long-term enterprises, such as technological development and science, suffer as public spending becomes limited. Investment in infrastructure is also made more difficult as more money is directed towards the military and security.

In the water sector, the incidence of water-borne diseases increases significantly and more potable water is becoming polluted. Many people have lost confidence in water provision from both public and private sectors as terrorist groups threaten to poison the water supplies. This leads to extreme price rises from institutions who guarantee 'safe' water. Conflict over water resources in semi-arid and arid areas becomes more common, and again there are terrorist attacks on dams and water pipelines. Private militia have set up resource enclaves of water abundance to protect supply for transnational corporations. Famines occur in conjunction with absolute shortages of water, and more people die every year.

4.4 Sustainable Water World

The Sustainable Water World (SWW) scenario also starts in the same fashion as the CWW vision, with some initial changes of direction. There is a realisation by the financial sector that investment in social institutions is essential for a sustainable future, and they are willing to concede slower growth for the sake of sustainability. There is thus considerable investment in the service sector and in the environment. A significant factor in this scenario is the development of the southern economies, which experience most of the world's growth and come reasonably into line with the northern economies. This growth, however, has been based on the lessons learned by the northern countries, and so environmental and social degradation are avoided.

The planet has become a global village where telecommunications result in free movement of and access to information, meaning the most remote areas feel connected. Alliances are formed between NGOs, governments and the private sector (especially transnational corporations, who now have a friendly face after accepting a social charter) and there is significant emphasis on public-private partnerships for service, including water, provision. Ironically, it has been realised that absolute numbers of people were never an important global problem at a time when population growth rates begin to fall due to a fair distribution of resources.

Technology has experienced significant developments, specifically in nanotechnology and telecommunications. Technology has also combined with existing local technologies (appropriate technologies) to create socially and ecologically acceptable solutions. New technologies have combined the principles of ecosystems with those of efficiency and holism.

Governance and institutional development have evolved from the lessons learned from previous eras, and the world has finally seen an end to unaccountable governments. Governance structures have become increasingly decentralised and now include a wide variety of representatives from civil society. Decision-making is now pluralistic and truly democratic, and decision-making structures are relied upon to resolve conflict through negotiation and consensus. This increasingly democratic trend removes much of the need for military and armed intervention. Consequently, the world sees less conflict and more cohesion. When there are problems that are beyond the capacity of the nation state to deal with – for example, drought related famine – the global community responds through the United Nations, which has become a mechanism for risk mitigation and minimisation.

Environmental controls are increasingly being managed by democratic global institutions that put in place regulations and management frameworks. Water was put high on the global agenda and was linked directly to development. New emphasis was put on the development of new, water-efficient technologies, and the management of local water resources by consortiums of private sector and local social institutions. Targets were set and reached on the adequate water supply for each individual, through a concerted effort by the global and national community. Water-borne diseases were considerably reduced through adequate service provision, and agricultural water is now efficiently used and allocated (Raskin et al., 1997). Water withdrawals were reduced to sustainable levels and water intensity reached a remarkable historical minimum. These advances were realised through the marriage of technology, global governance and lessons learned as well as the use of social water management institutions.

4.5 Summary

The root of all the three scenarios or visions is the Conventional Water World (CWW) which has its basis in current trends and practices. The CWW's driving forces then diverge, at some point, to produce either the Water Crisis or the Sustainable Water World (see Figure 8). As such, attention can be focused on those areas within the CWW that need attention and have the potential to alter the development trajectory to a more sustainable future. As the current climate is dominated by market-based approaches to development, attention needs to be paid to how to regulate or direct this development (this may be especially difficult as the neo-liberal approach emphasises freedom of investment and a deconstruction of protective barriers). In relation to social security, there are a number of critical issues which include:

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- *The relationship between the private sector and public water supply.*
  As governments start to back away from service provision, as it is increasingly put into the hands of the private sector, there is a risk that social institutions will be overridden or ignored in favour of profit motives. There is, therefore, the risk that much local knowledge and management capacity will be lost through this process. In addition to this, as capacity is lost, freshwater ecosystems will also suffer from the lack of productive management from local institutions. Private sector operations may maintain ecosystems to ensure minimum water provision, but will rely more heavily on technology, rather than ecology, to provide water reproduction (i.e. through water treatments, purification and allocation). Box 7 provides an example of how the private sector was able to expand water supply and recover its costs in South Africa by expanding the supply. This example shows that private sector companies can recover their costs in the face of threats, without having to take account of local institutions. However, as state public spending is reduced, the private sector can be encouraged by the state to incorporate the interests of such institutions.

- *Systems of governance and the provision of water resources.*
  In some societies, local institutions will be able to negotiate with the central government with regard to water provision. Communities can form and support groups, building upon community initiatives to improve access to water resources and to lobby government. A more common form of organisation may result from a context of unaccountable governments, that is as government structures do not deliver, civil society provides for its own population. Box 8 provides an example of proaction by an urban community in Pakistan. This demonstrates the resilience of communities in the face of water shortages but also shows a worrying trend where neither the private sector nor the government demonstrates a willingness to provide services. This form of cooperation and mobilisation is more often found in urban situations, where people have more spending power and inadequate water supply and sanitation represent a real risk. In rural areas, community initiatives are also found, but may take more time to become apparent.

- *Agricultural expansion and the marginalisation of communities.*
  The expansion of agricultural land used for the production of cash or export food crops has often led to the marginalisation of local communities. Much of this land has often been irrigated and, since all forecasts show an increase in irrigated agriculture, it is likely that this trend will continue. A challenge for many water-deficient nations will be to reduce their export of 'virtual water' (i.e. through the export of water-intensive agricultural products), and either concentrate on rain-fed agriculture or begin importing virtual water from water-abundant regions. This could see the creation of important regional markets; for example,

Box 7 South Africa

Umengi Water Board: Expanding Access to Improved Levels of Services through the Private Sector

Umengi Water, the largest utility in the province of Natal in South Africa, takes a long-term view on the provision of water supply to a catchment of 24,000 km and a population of 5.5 million (of which 1.5 million are rural). Development and growth in this area have put the water resources under stress. The utility identified a major source of pollution to be from the discharge of raw and untreated sewage into the basin, resulting from increased urbanisation and informal settlements. In addition, soil erosion in the headwaters was causing increasing silt loads in rivers and reservoirs. As a result, the cost of water supply to urban users was increasing due to expensive treatment costs.

To counter these long-term effects, the utility started providing water supply to rural areas, also demonstrating that services could be provided jointly to rural, suburban and urban areas in a cost effective manner with full cost-recovery for the operations and maintenance cost. The utility covered the capital cost by a capital subsidy from the urban to the rural areas which, when a broader perspective is taken of the environment and long-term cost-price relationships, is essentially seen to be of benefit to the urban dwellers.

Source: Nigam and Ghosh, 1995

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Sudan could reduce its consumption of virtual water in, let's say, the Gezira Strip, and starting importing virtual water from, an area such as the Ugandan highlands. This purely hypothetical example is meant to illustrate that there can be alternatives to agricultural expansion in water-deficit areas and the consequent marginalisation of communities (although it is recognised that the former example creates wage-labour opportunities).

- *Industrialisation and water consumption.* The facilitation of foreign direct investment through global legal financial mechanisms, such as the multilateral agreement on investment, creates new threats to water availability and ecosystem management. Although there is a trend towards low-input, high-output industries and dematerialization, nations will always need a certain level of industrial production. The export of highly resource-consumptive industries to developing countries is already taking place, and represents a significant risk to water resources in the present context of weak legislative environments. For example, a large aluminium smelter is currently being built near the port of Maputo, in Mozambique, which has necessitated that a separate water pipeline be constructed that will supply the smelter with its considerable water needs. It is essential that global attention is paid to the process whereby the developed economies become increasingly 'clean and sustainable' and the developing countries, in their desperation for inward investment, become the home to the world's dirty industries.

In the face of an economically driven world, it is difficult to look into the future and see the possibility of a socially responsible reality. In the push for profit, governments and the private sector run the risk of losing the social institutions that created them in the first place. Social institutions that govern the security that is derived from access to water resources also mask deeper processes that are fundamental to a sustainable water future:

Recognising the salience of contextual sensitivity constructing a water management institution, one must not only consider incumbent formal institutions but also include a focus on the informal institutions carrying socially transmitted information preventing, permitting and prescribing social and political behaviour (in Swain and Stålgren[1], 1998: 18).

The Conventional Water World and the Water Crisis world hold many threats for the continued existence of many of the institutions which ensure water security for large sectors of the planet's population. It must be part of our remit to ensure their survival.

Box 8 Pakistan

Proaction in Pakistan

About 40 per cent of Karachi's population live in squatter camps called Katchi abadis, which have developed at the edge of the city in the last 25 years. The rich in Karachi have modern sanitation and underground sewers, whereas those in the camps have only bucket latrines and open sewers. In 1970, the government formally recognised that these settlements were here to stay, which enabled the inhabitants to buy titles to their homes, giving them a sense of permanency. In 1980, communities in the Katchi abadis formed an organisation called Orangi Pilot Project (OPP) to tackle the sanitation problem in one of these abadis. Previous to this, the residents had formed numerous community associations that lobbied the government for sanitation, but there had been no response. The OPP was set up to develop a sanitation system themselves, after repeated requests to municipal authorities had got them nowhere.

Seventeen years later, virtually every home in Orangi has a flush toilet connected to an underground sewage pipe. Each family invested about one month's income to buy materials and hire labour. Significant improvements are now seen in school attendance, loans for small businesses and health. The key Orangi lessons are that adequate sanitation is fundamental to improving living standards; people are willing to pay for sanitation if the costs can be controlled through the community; and collective efforts of ordinary people can push aside the roadblocks of bureaucracy.

Source: Khan, 1997

1. This excerpt although taken from Swain and Stålgren (1998), is based on the work of March and Olson (1989); North, (1990) and Elster (1989).

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5. Future Strategies

5.1 Setting the Scene

The approach set out in this paper has emphasised the links between the management of freshwater ecosystems and the social security of communities around the world. In this section, we consider a range of strategies that could contribute to this process. It is important to recognise that social security issues alone will not be the basis for choice of strategies. Such choices need to be based on a holistic appraisal of management needs and priorities. What is presented here is intended to stimulate a recognition of social security maintenance as one of those needs and priorities.

The goal of these strategies should be to reduce vulnerabilities and uncertainties, through providing greater choices and ensuring that the choices made reflect the inherent spatial and temporal variability of both freshwater resources and patterns of human need and action. They should also work towards building a stronger societal consensus and more stable institutional environment for the future management of freshwater resources. From these departure points, such strategies should:

- Empower local communities to manage resources in a fair, sustainable and effective manner.
- Develop institutional structures that are transparent, legitimate and representative, and that integrate local communities into the wider society.
- Give a better understanding of the role of freshwater resources in social security, and of the value of these resources.
- Provide an appropriate legal and regulatory framework that clarifies rights and entitlements, and specifies responsibilities and obligations for the maintenance of freshwater ecosystems and social security.
- Prevent or mitigate conflicts over freshwater resources management at all levels, from the local to the international.

The general approach should be to recognise and build from what is good within existing management regimes, while working to change or adapt the negative aspects of these regimes. In this, there is a need to think ahead – to anticipate where existing trends are moving and what the challenges of the future will be – for many of the strategies presented here are long-term in nature and will have consequences for future generations as much as for the present one. Such reference to the future, although inevitable, is difficult as we are all aware of the fragility of predictions and projections. What it does mean is that any such strategies should be flexible and should have the capacity to cope with uncertainty.

This paper is one of three commissioned by IUCN to provide building blocks for the overall development of a 'vision' on water and nature. To ensure that there is a level of coherence between the three papers, where possible, the strategies identified here are divided into:

- Adaptation Strategies: strategies that recognise that it is either not possible or not desirable to remove a specified source of vulnerability and consequently seek to enhance capacities to cope with it. An example is the threat posed by extreme events, such as cyclones, or trends that are beyond immediate control, such as global warming.
- Mitigation Strategies: strategies that are intended to significantly reduce or eliminate defined threats or sources of degradation; for example, the removal of a particular point of pollution or new legislation to clarify rights over resources.

There are, however, key aspects of the challenge that are not directly connected to individual types of vulnerability and consequently do not fit easily into this division between adaptation and mitigation. These are issues related to the structural conditions of society within which the management of freshwater ecosystems and the reproduction of social security occur. In particular, these reflect the structure of institutions within which different forms of interaction take place, and the underlying social conditions within which these institutions operate. In other words, these define the context within which individual strategies, whether for adaptation or mitigation, will be placed. There is a clear need to develop strategies to address these issue; indeed, if there were not, this paper would not be needed. We consequently consider strategies connected with these structural issues first.

5.2 Strategies for Structural Change

These strategies are intended to change the societal and institutional context within which threats to social security and freshwater ecosystems are addressed, whether through adaptation or mitigation approaches. The emphasis is, inevitably, on policy and institutional issues, with in particular an emphasis on moving towards the greater horizontal and vertical integration discussed in section 1. Actions are needed at all levels, from the local to the global, but there is a particular need to look carefully at the structure and operation of the state and the links between state agencies and the wider civil society. The key areas of such actions are:

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5.2.1 International Cooperation

The origins of many threats to ecosystems and social security are beyond the borders of many individual states. They can be global; for example, the consequences of climate change. They can represent hydrological dynamics within a river basin that crosses national borders: upstream pollution or overabstraction. Addressing these threats entails cooperation between countries, not least to try to remove the threat of overt conflict. We have seen that there are positive examples of cooperation (such as the Bangladesh-India agreement on the water of the Ganges), but even these tend to be piecemeal and there is rarely a perspective that recognises the overall dynamics of such threats (e.g. a comprehensive Ganges-Brahmaputra Basin agreement).

What does exist is an emerging international consensus on the direction and goals of freshwater ecosystems management (see Table 11). This consensus emphasises the importance of holistic approaches that define rights and responsibilities and that integrate the preservation of ecosystem functions as a central goal of water resources policies. Major international initiatives, such as the work of the Commission for Sustainable Development and the GEF Operational Strategy, provide an opportunity for articulating the relationship between social security and the management of water resources with the goal of building a clearer international consensus and influencing the policies and approaches of individual nations and institutions.

This consensus needs to be built on through the following strategies:

- The development of coordinated strategies to cope with threats such as global warming, major storms, floods and droughts that affect the integrity of ecosystems and the security of people. This should include joint risk assessments, collaboration on early warning and response systems, and mutual aid when disasters strike.
- The establishment of river basin forums that integrate all countries (including governments and representations from civil society) within major river basins where there are threats to ecosystem integrity or social security. Such forums will rarely have formal powers, but should be a basis for reaching better understanding and establishing consensus on the future of the river basin. They can also play a crucial role in the defusing of conflicts over the sharing of water resources along the river basin.
- Creating a better understanding of all aspects of freshwater resources and their uses within river basins and across international borders through shared research, information and monitoring systems. This should include both the ecological dynamics and the full valuation (including social security values) of the resources and their uses.

Table 11 Summary of Major Policy Statements and Declarations vis-à-vis Water

Stockholm Conference on the Environment (1972)
Water was not a prominent issue at this meeting. The document from the conference calls, however, for abatement of pollution in developed countries

Mar del Plata (1977)
This was an 'historic conference' and the first, and so far the only, UN conference entirely focusing on water. In the Mar del Plata action plan, recommendations are discussed in detail. In retrospect, the implementation of the action plan has been far from satisfactory. It did, however, urge for the launching of the *International Drinking Water and Sanitation Decade.*

Nordic Fresh Water Initiative (1991)
Produced the Copenhagen Informal Consultations with a broad representation from governments and international organisations, and the Copenhagen Statement, which emphasises two key principles for future strategies for sustainable development and management of water resources for rural communities:
1) Water and land resources should be managed at the *lowest appropriate levels;*
2) Water should be considered as an *economic good* with a value reflecting its most valuable potential use.

International Conference on Water and Environment in Dublin (1992)
500 participants endorsed four guiding principles in the Dublin Statement:
1) Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.
2) Water development and management should be participatory, involving planners and policy makers at all levels.
3) Women play a central role in the provision, management and safeguarding of water.
4) Water has an economic value in all its competing uses and should be recognised as an economic good.

Global Environment Facility Operational Strategy
Focal point for GEF approach, with sections on International Waters, Biodiversity and Climate Change.
On international waters, identifies 4 key concerns:
1) Degradation of the quality of transboundary water resources.
2) Degradation of aquatic habitats in coastal areas.
3) Introduction of non-indigenous species that disrupt aquatic ecosystems.
4) Excessive exploitation of living and non-living resources due to inadequate management and control measures.

UN Conference on Environment and Development (1992)
Links between the environment and development recognised at the highest political level. Agenda 21 consists of 40 chapters. Freshwater resources is dealt with in Chapter 18 and systematically deals with seven programme areas. Most of the seven programmes cover the same issues as the eight recommendations in Mar del Plata, with the exception of urban issues and climate change.

World Bank Policy Paper on Water Resources Management (1993)
Based on lessons of experience, the Bank aims at the adoption of a comprehensive policy framework and treating water as an economic good, combined with a decentralised management and delivery structure.
The policy framework is consistent with the Dublin Statement as well as with Agenda 21.

Commission for Sustainable Development (1994)
The CSD in 1994 urged UNEP, FAO, UNIDO, WHO, WMO, UNESCO, UNDP, the World Bank and other relevant UN bodies to strengthen their efforts towards a comprehensive assessment of freshwater resources of the world, to be presented at the CSD in 1997 and at the UN General Assembly. The CSD also invited governments to cooperate actively, specifically identifying the Swedish government. The SEI was commissioned by the Swedish government to actively work on the project.

OECD DAC (1994)
Largely endorses the Dublin principles.

Source: Lundqvist and Gleick, 1997

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5.2.2 Policy Reforms

Many aspects of vulnerability and the degradation of freshwater ecosystems are rooted in incomplete or inappropriate legal and policy frameworks at the national level. Above all, it relates to who has control, with many countries having a long history of the state expropriating rights over freshwater ecosystems and then failing to use these powers in an effective manner. This need for a range of policy reforms should centre on:

- Water and Land Tenure Laws: providing a legal basis for assigning rights and entitlements (including customary and communal rights to common property resources) is crucial for the maintenance of both ecosystems and social security.
- Policy Priorities in food production, industrialisation and water resources allocation are all critical. Past policies that have given primacy to high-intensity grain production and/or industrialisation with no regard to resource sustainability have been particularly damaging. All policies need to take full account of their wider impacts on people and ecosystems.
- Investment and Budgetary Priorities: the state will continue to play a key role in many parts of the world. The allocation of resources to ecosystems maintenance and meeting the needs of vulnerable groups is critical in establishing coping strategies. Policy makers need to pay particular attention to the nature and consequences of existing subsidies and economic incentives, and to develop and prioritise new incentive systems that place ecosystems maintenance and sustainable management at the centre of policy goals.
- The establishment and enforcement of appropriate standards (both quality and quantity) for the use of water resources, based on the dual goals of enhancing social security and conserving freshwater ecosystems. These standards need to be integrated into an effective regulatory environment, based upon an appropriate and adequately-resourced institutional framework to ensure that standards are met.
- Defining and implementing meaningful pricing or cost recovery mechanisms that reflect the true value of the resources and that ensure 'polluter pays' principles are implemented.

5.2.3 Institutional Restructuring

The need for more accountable, effective and devolved institutions has already been discussed. There are trends towards this in many parts of the world. These need to be encouraged through the demonstration of the importance for these trends for the maintenance of both social security and ecosystems integrity. The specifics of such strategies will vary from place to place, but general trends should include:

- Improving Efficiency: too many state agencies, in particular, are centralised and bureaucratic in nature, and operate to prescribed rules and procedures with little thought as to why things are done the way they are. There is a move in many organisations (including major multinationals) towards management structures that devolve authority to the operational level and operate through shared value systems, cultures and trust. These principles need to be inculcated into government agencies that influence the ways in which freshwater ecosystems are managed.
- Multi-agency Subsidiarity: there is a need for multiple agency involvement, including central government departments, local government, NGOs and locally-based community organisations in the management of freshwater resources. The division of responsibilities between these different levels and workable protocols for their interaction and coordination are similarly essential. This is an inherently complex process which involves redefining mandates and levels of authority, redirecting budgets, capabilities and facilities, and establishing a clear and shared vision on where water resources management is going. This type of restructuring will bring benefits in both more effective operations (and lower costs) and a clearer social consensus on what should be done and why.
- Linking to Democratisation and Decentralisation: the social consensus should also be part of a wider process of development and change. Many parts of the world are seeing strengthening democratic processes and the decentralisation of state structures. Both are desirable trends, as both involve the wider civil society in decision-making and produce a stronger link between the local level (where resources and managed and social security operates) and external agencies. These links are also essential in providing the mechanisms for the arbitration of potential conflicts within or between different communities over the use and preservation of freshwater ecosystems.
- Strengthening Local Institutions: the examples cited above have demonstrated the potential of local institutions in water resources management, but it is important not to idealise these initiatives. Although they are well-developed in some areas, they are weak in others and will need considerable support if they are to become the focal point of local-level management of water resources and infrastructure. This local-level capacity building is the basis upon which many strategies should be based, for without it there is no hope of implementing reforms that rely on the active involvement of local groups.
- Improving Understanding and Planning Capabilities: knowing what to do and how to do it is the key to sustainable changes. This is, in turn, dependent on good information about the present situation and effective tools to analyse and predict the consequences of change. There is often a dearth of both, with limited and technically-oriented data and planning tools that are rarely widely accessible. There is a clear need to develop information bases and analytical tools that are accessible to all and that provide a structure within which social consensus on what to do can be based.

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5.3 Adaptation Strategies

These strategies centre on the development or enhancement of coping mechanisms where people and communities can improve their abilities to live with forces that they cannot do anything about. The development of improved capacities to cope with existing trends is a critical issue. In some cases, this will build on what is already there (and this includes supporting existing coping strategies that are being undermined). In others, it will entail a whole new set of responses to threats that are perhaps new, themselves. In both cases, the overall objective is to create the circumstances where society as a whole works to support those sections of the community (and those ecosystems) that are most at risk from these threats.

In this, the emphasis is on the empowerment of local communities: the creation of circumstances where they have greater control over their own lives and greater choices about how they will respond to the challenges they face. This does not mean, however, that all actions are aimed solely at the local level, for there is a range of actions needed at all levels, from the individual to the international, and the success of the adaptation (or mitigation) strategies identified here will often be contingent on the structural changes outlined above.

The main focus of such adaptation strategies will consequently be to improve community capabilities to manage freshwater ecosystems, and especially common property resources, that are experiencing change caused by forces beyond control (such as climate or economic change). The direction of these improvements will be to maximise the sustainable productivity of these ecosystems, but to do so in ways that do not threaten their long-term integrity. The details will depend on local conditions (economic and ecological), but the goal should be to recognise and find the balance between all potential goods and services these ecosystems offer. Within this broad field, some specific strategies are:

- Ensuring that the communities have clear rights and entitlements, supported by the jurisdiction of appropriate external agencies.
- Working with local communities to adapt traditional harvesting of water or water-based plants and animals to reflect changing sustainable potentials.
- Identifying new potentials, including non-consumptive uses such as ecotourism, to compensate for declining resource utility from traditional forms of exploitation.
- Developing new technical options, including management regimes and technology choices, that conserve the resources more effectively.
- Identifying alternative sources to meet existing needs, such as replacing wild gathered fish with aquaculture, or using groundwater instead of surface water for domestic needs.
- Assisting local communities to develop disaster response capabilities where environmental threats from storms, floods, droughts and so on are more severe. This should include both organisational issues and structural works such as re-establishing mangroves or constructing refuges.

5.4 Mitigation Strategies

Mitigation strategies are those approaches that are aimed at lessening or removing the effects of threats to freshwater ecosystems that undermine social security. In these instances, the basic assumption is that something can and should be done to deal with immediate threats. They are typically more amenable to local control, but this does not mean that they are purely localised issues: they are often as dependent upon the wider context as the adaptation issues discussed above. It does mean that the central thrust of these strategies is to enhance the capability of local communities and the wider society to reverse many of the threats to freshwater ecosystems found in different parts of the world today. Again, in most cases there will need to be a combination of social/institutional and technical/management interventions. Examples of such mitigation strategies are:

- Ensuring that the communities have clear rights and entitlements (always a prerequisite), supported by the jurisdiction of appropriate external agencies, as ecosystem degradation is often linked to inappropriate or uncertain rights.
- Creating effective local institutional capacities to provide a vehicle for empowering local communities and establishing sustainable freshwater ecosystems management.
- Creating mechanisms for conflict mitigation between local communities and outside agencies, between different local communities and between groups within a locality. This is often essential for reversing unsustainable practices that competition creates.
- Identifying and implementing sustainable multiple use management strategies that are based on reversing degrading practices while retaining the benefits that the resource uses bring.
- Developing a better understanding of both the origins of present problems and the options for change, with a key challenge being to ensure that such knowledge development involves all stakeholders and integrates both indigenous and external knowledge systems.
- Defining appropriate interventions, including investments that are both technically sound and economically wise. This will often require some level of external resources, but should ensure that there is an involvement of local resources as well.
- Developing appropriate resource charges and cost recovery mechanisms, to ensure that the users of freshwater resources pay for the benefits they receive. Such charges should be linked to local abilities to pay, with local communities receiving the benefits of such cost recovery.
- There is a clear need to create a political consensus for many of the actions needed to mitigate unsustainable ecosystems management. This in turn means that there is a need for effective advocacy within civil society to provide an understanding of the implications of present paths and the need for change that may entail short-term costs to ensure long-term benefits.

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6. Freshwater Ecosystems, Social Security and Creating a Vision

The point of departure for this paper was identified in the first section as the development of a Vision on Water, Life and the Environment. This point of departure may have got lost in the discussion in the last four sections, but this last section is intended to bring us back to this beginning. The issues raised in this paper are consolidated here as a series of specific points that are meant to provoke a reaction. It is hoped and intended that the reader will consider each of the points raised below in relation to her/his life: both (for many) as a professional, whose working existence is based around dealing with these issues, and as a citizen, a member of a particular society and the global community whose future is as dependent on these issues as that of the rest of the planet.

The Vision

We all face an uncertain future, surrounded by fears but supported by hopes and dreams. What should the future of water be, for you and for the community in which you live? Where would you hope that your society and the global community will be in the next century, and how can the management of freshwater ecosystems contribute to this through reducing uncertainties and providing greater security?

The challenges

The challenges are to manage freshwater ecosystems in the 21st Century in ways that are wise; that recognise the interdependence of different parts of the hydrological cycle and the needs of different sections of the community. In defining our goals for the management of these ecosystems, how far can we incorporate their role in providing greater security to livelihoods? Can we make the best use of all their potentials in ways that do not undermine their integrity? Can we bring together people, communities and nations to reach a consensus on the distribution of these benefits without the conflicts that threaten to be the source of insecurity and suffering in the 21st Century?

The world today

All around us we see worrying trends, as freshwater resources are degraded by careless use and abuse, more conflicts emerge and the poor access to these resources means that too many millions still suffer from illness, poverty, drudgery and insecurity. Amid this gloom, however, there are signs of hope – in the ingenuity and creativity of many communities working together to overcome the challenges they face, and in the better understanding of these human potentials that is now emerging. Can we learn from today, both to tell us what not to do in the future and to find the experiences and examples that form the basis of hope for the future? More importantly, can we help inform others of these hopes and create the social consensus for change that is so important if the signs of despair are to be overcome?

Creating understanding

These issues are far from simple. Too often a real consensus is not possible because people start from different assumptions and analyse the problems with different reference frames. Can we find a conceptual framework that helps inform us and helps us to inform others?

What does the future hold?

The future is always an uncertain place, but we can identify trends that give us direction and provide insights into the consequences of certain courses of action (or inaction). To borrow from Sergio Leone, we can see The Good (a transition to sustainable freshwater ecosystems management where their contribution to social security is conserved and enhanced), The Bad (a conventional world, with 'business-as-usual' – meaning a gradual deterioration of the resources and declining social security) and The Ugly (a water crisis world in which ever more demand chases ever declining resources, and oppression, conflict and despair are the lot of us all).

What can be done?

What is clear is that these challenges need vigorous and sustained actions now if they are to be addressed. The key, in the context of social security and freshwater ecosystems management, is to create the social and institutional context within which sustainable management and the empowerment of the marginal is possible. This means different things in different places. What should (and can) be done first? How can the power of entrenched interests be overcome? How can we ensure that we really reach and empower the most in need to take control over their own lives and have greater choices to overcome the challenges they face?

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Glossary: Defining the Concepts

Accessibility: describes the proportion of a given resource endowment that is available for use. It is socially differentiated, in that different people and groups will have different types of access. It goes beyond entitlements to include physical access (e.g. can the resource be reached without a level of effort greater than the resource value) and technical access (can a potential resource actually be harvested with available skills and tools).

Accountability: key features of institutions are who makes decisions, the basis from which they derive their authority and to whom these decision-makers are accountable (that is, who monitors and sanctions the decisions made). In developing effective and representative institutions, responsibilities for and the consequences of actions should be transparent and accountable, and the policies and decisions should lead to clear, effective and legitimate uses of the resources (e.g. government revenue, aid projects) made available to implement them.

Civil Society: Dasgupta (1993) defines civil society as "the sphere of autonomous institutions, protected by the rule of law, in which men and women may conduct their business freely and independently of the state". It is a concept that is used to identify all non-state institutions that influence the behaviour of individuals and groups within a society. It includes both formal organisations, such as trade unions, political parties, voluntary associations and NGOs and non-formal institutions, such as religious, ethnic or regional groups and social groupings based on place or livelihood (such as fisherfolk).

Community: the social groupings that the individual household lives within. The social and institutional structures of local communities are often extremely complex and locality-specific, but they reflect differing combinations of the place (the locality or neighbourhood) and the people (the kin, religious, ethnic, occupational grouping or other social and economic characteristics) where an individual household lives. In these, communities are usually tied together by a set of common interests and also typically have shared histories and cultures.

Coping Strategies: are the strategies that the poor, and others, adopt in the face of threats, such as resource degradation, market collapse, conflict or other forces that affect the viability of their livelihoods. In these, the household will seek to deploy the different assets they possess to best effect within the range of choices they possess. Typically, the most vulnerable have the least choices and will consequently adopt risk minimisation strategies to avoid the emergence of such threats.

Efficiency: making best use of the resource potentials. The measurement of efficiency should not be based on traditionally narrow economic or technical criteria that tend to look at individual activities (such as irrigation or waste disposal) in isolation. Rather, efficiency needs to be based on the best use of the total package of resource potentials, or endowments, within the hydrological system.

Entitlement: an entitlement is the set of alternative commodity bundles that can be acquired through the use of various legal channels of acquirement open to that person or group, using a totality of rights and opportunities that he or she faces. This starts from a baseline of an original bundle of resource potentials, which is the endowment. Entitlement is a concept founded on social acceptance of the rights of specific people to access the resources. This can be based on ownership (and other forms of legally-defined entitlement) or on social custom (including traditional rights not enshrined in law and at times not recognised by the state or other external agencies).

Equitability: activities which enhance equity – with particular priority given to the poverty and gender dimensions of development and resources management – are prioritised, to reflect that true efficiency and sustainability will only be met where policies are based on meeting the needs of all stakeholders.

Equity: the use of the resource by one user should not harm other users now or in the future. Where choices have to be made between different possible uses or users, then these choices should be based on greatest need, not economic or other forms of power. Of course, this raises the question of who makes these choices; something to which we return below.

External Environment: the legal, political, social, economic and institutional factors that link people and places into regional, national and global systems. This includes the nature and operation of government, the structure and strength of civil society (those non-state institutions and organisations that also regulate social and economic processes), and the operation and control of markets.

Freshwater Resources: come in many forms:

- In different places in the hydrological cycle: surface water in rivers, lakes and marshlands, groundwater in aquifers or, closer to the surface, as soil moisture, locked up in glaciers, snow and ice fields, and in the atmosphere and oceans.
- The fish, crustaceans or other animals, and the plants of all sorts that are found within the water itself or in wetland areas that make up freshwater ecosystems.
- The 'services' (such as energy from hydropower, water as an environmental 'sink' for the disposal of waste products, or recreational and aesthetic values of water and associated ecosystems) that can be derived from water resources.

Institutions: processes that lead to regularised patterns of decision-making and behaviour. The idea of an institution can be viewed from two distinct perspectives:

- A restricted perspective: an 'organisation' that is a formal agency which has a distinct identity, some form of legal status, a clear and, in most cases, written constitution or set of operational rules, and a defined purpose.
- A broader perspective: all structures that produce forms of regularised behaviour. This includes formal agencies as an important but not complete representation of institutional processes in resource management. It also includes other regulatory mechanisms: norms, customs, values and social conventions that influence the resource choices that people make, but which are not enshrined in or channelled through any formal organisational structures.

Legitimacy: is a basic concept in entitlements theory. It means that the decisions made over the allocation and use of resources is open, fair and accepted by all concerned. It is dependent upon an institutional framework for decision-making that is representative of all interests (including ones that may not directly participate in decision-making). In this, ecosystems should be seen as an interest, or stakeholder, in the process of making decisions concerning the management of freshwater resources.

Livelihood: has many definitions. Carney (1998) presents one based on the work of Robert Chambers and Gordon Conway that is better than most: "A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base" (p. 4).

Livelihood Activities: are the sets of actions through which households gain their means of survival. These are conventionally divided into two categories:

- Production Activities: those activities that produce goods and services which contribute to 'income' (the value of goods and services that are actually or potentially tradable).
- Reproduction Activities: these are sometimes called household maintenance activities, and are those activities, such as childcare, cooking and cleaning, that are not tradable but which are nevertheless essential for the wellbeing of household members and the reproduction of the conditions through which a family survives.

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Livelihood Assets: are the means of production available to a given individual, household or group that can be used in their livelihood activities. These assets are the basis on which livelihoods are built and, in general, the greater and more varied the asset base the higher and more durable the level of social security. Carney (1998) suggests that there are five dominant forms of livelihood assets (arranged in a pentagon in Figure 1).

- Natural Capital: the natural resource stock from which resource flows useful to livelihoods are derived.
- Social Capital: the social resources (networks, membership of groups, relationships of trust, access to wider institutions of society) upon which people draw in pursuit of their livelihood.
- Human Capital: the skills, knowledge, ability to labour and good health important to the ability to pursue livelihood strategies.
- Physical Capital: the basic infrastructure (transport, shelter, water, energy, and communications) and production equipment and means which enable people to pursue their livelihoods.
- Financial Capital: the financial resources which are available to people (whether savings, supplies of credit, or regular remittances or pensions) and which provide them with different livelihood options.

Precautionary Principle: the idea that where serious uncertainties exist, the potentially damaging resource exploitation should not take place until it can be demonstrated that the risks are within acceptable limits.

Resilience: the ability to withstand the impact of trends and shocks. In social security terms, this is the extent to which social institutions provide a 'buffer' for individuals and households against these external impacts on their livelihoods.

Resource Conflicts: a key characteristic of existing patterns of resource allocation and social relations is the potential for overt or repressed conflict. Such conflicts can be direct and material: for example disputes over access to common property resources. They can be structural and reflect inherent power relationships between genders or social groups.

Resource Degradation: resource utilisation that diminishes the total actual or potential resource endowment, now or in the future. This includes the impacts on the process (i.e. the ecosystems) through which these resources become available. As such, to understand degradation, we need to look at the full effects of water resources use on water availability (including spatial and temporal variations in this), on water quality for different uses, and on ecosystems' viability.

Resource Endowment: the total potential package of goods and services that can be extracted from a given resource base. There are two sides to this – the present endowment (the total of goods and services available from existing resource conditions) and the potential endowment – the maximum utility that could be obtained under optimal conditions (or the ecological potential).

Scarcity: for water resources, the limited availability of, or limited access to, the many different services water resources provide. Scarcity can mean that there is simply not enough water available (leading to questions about how what is available is allocated), but for many the issue is the quality of the water resources, the consequences of different, incompatible uses competing for the same resources, or the social, economic or institutional barriers which limit access to resources which are abundant in an absolute sense.

Social Security: is something experienced by individuals but produced within societies. It has material and non-material manifestations, including both the extent to which people are able to meet their most basic of needs (things such as water, shelter, good health and food) in a secure manner and the freedoms people enjoy from threats of violence, prejudice, oppression and environmental risks. The ultimate notion of social security is where social groups and institutions are able to guarantee their own reproduction: i.e. they have sufficient control over their lives that they, and the functions they perform for their members, are self-replicating.

Subsidiarity: the process of institutional change that devolves decision-making authority to the lowest appropriate level, ensuring that the power and resources to make such decisions meaningful ones are similarly devolved. This is an essential prerequisite for engendering greater participation in development processes.

Sustainable Management: management that makes best use of present resource potentials and does not diminish the availability of these resources in the future or the integrity of the ecosystems through which these resources are provided.

Vulnerability: vulnerability is both a condition and a determinant of poverty. It reflects the extent to which livelihoods are at risk from factors, trends and shocks beyond their control. This includes both environmental forces (such as drought) and anthropogenic forces (such as market prices). Watts and Bhole (1993) suggest that vulnerability has three coordinates. First, the risk of, exposure to shocks and trends. Second, inadequate capacities to cope with shocks and trends. And third, the risk of severe consequences of, and attendant risks of slow, or limited poverty (resiliency) from crisis, risk and shock. Vulnerability is closely linked to social security, as the ability to cope is predominantly a reflection of the social and institutional support framework that surrounds individual households.

Vulnerability Context: the vulnerability context is the trends of change and variability in those factors that affect livelihoods, and in particular describes structural processes that can materially disrupt different aspects of the livelihoods process.

Water Resources Uses: water resources have many uses, including as an input into agriculture, as a basic need for household maintenance, and for a myriad of other types of production (industry, navigation, fishing and the harvesting of other life forms, power generation, waste disposal, etc.). They also have important aesthetic, cultural and spiritual values. Some uses are consumptive (their use means that the service they provide is not subsequently available to other users), while others are non-consumptive (their use does not affect the future availability of the service the resource provides to others).

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Freshwater Ecosystem Management & Social Security

Final Statement and Workshop Report

Chair:

Atiq Rahman

Coordinator:

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Final Statement

Vision for Water and Nature Workshop, Harare, Zimbabwe, April 13-15, 1999

Vision

A future in which all people are ensured secure access to safe and adequate water resources to meet their needs and rights in ways that ensure the integrity of freshwater ecosystems.

Goal

The goal is to have water resources for food security, life and health, as well as resources for the maintenance of livelihoods and non-consumptive processes and products such as biodiversity, nutrient cycling, recreational, aesthetic and cultural values. This should be within a context where the management of water resources enhances both social security and equity and the viability of the ecosystems within which these resources are found.

Challenges

We see a world where current conditions and trends create formidable challenges:

The ecological challenge

To reverse trends in the degradation of freshwater ecosystems and even increase the abundance and quality of freshwater ecosystems through rehabilitation and remediation strategies. To reverse increasing pressures upon these ecosystems, which will grow through increased demands for and conflicts over water resources, and greater variability and uncertainty in ecological and climatic conditions.

The human challenge

To engender greater security and equity within and between households, communities and nations in an urbanising and increasingly integrated world, where poverty and inequality remain rife, population and consumption pressures are increasing, conflicts are ever-present and social structures, norms and expectations are changing.

The institutional challenge

To build efficient, representative and sustainable institutions for the management of freshwater ecosystems, which see reduction in the vulnerability of both these ecosystems and social security as prime goals; which integrate government, private sector and civil society; and which recognise that many communities whose security is linked to access to freshwater ecosystems are increasingly disenfranchised as their control over these resources is eroded.

Establishing a Process of Change

To move towards realising the goals, a change in freshwater resources management is required. Sector-oriented approaches must give way to integrated water resources management, based on a process that integrates the needs and interests of all stakeholders, and that fosters social security and ecosystem protection and rehabilitation, in terms of biodiversity and natural processes. This process of change will take many years to come to fruition, and is in many ways the heart of the vision to which this analysis on freshwater ecosystems and social security is a part.

To create this process, institutional reforms have to take place at local, national and international levels. This process should not be isolated from wider social and institutional changes, but should build on these to improve the institutional responsiveness to social and ecosystem needs, and the adaptability of institutions to a changing context. For example, it is important to recognise and work with existing grassroots community-based management initiatives to take full advantage of the groundwork they have already laid. Institutions and the private sector will need to be more accountable and oriented towards the local delivery of services and management of ecosystems. This requires strong national and regional governmental and non-governmental institutions to establish an integrated and transparent decision-making process, and to create the conditions through which social mobilisation can take place and changes in government institutions are engendered.

A key element of the process of change is the promotion and establishment of actions at the community and local levels, which empower individuals and communities and enhance socially acceptable rights, entitlements and access. This requires understanding of and awareness about potential trade-offs between economic development and social and ecological degradation and opportunities for diversification and flexibility in terms of resource use. All aspects of the process, however, cannot be addressed at the purely local level; there is a need for institutional changes that integrate local structures into wider processes of resource management, based around catchment units. It is at these levels that conflicts within and between communities, and the range of trade-offs between the interests of different stakeholders, can be resolved. In this context, the impact of globalisation weakening the national states, and affecting national and local economies, has to be considered.

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The process of change would establish the conservation of freshwater ecosystems through a more efficient and equitable use and management of water resources. It focuses on reversing the current trends in freshwater ecosystem degradation, through maintaining and enhancing the capacity of these systems to provide goods and services whilst conserving biodiversity, natural processes and non-monetary ecosystem qualities. It also recognises, and integrates as a central goal, the role of freshwater ecosystems in the maintenance of social security.

Framework for Action

Both the challenges and the actions to meet these challenges are formidable. The process of change set out above will take a long time to materialise and will require a strong will and adequate resources from all parties to bring it about. There will be a need for some coordination, but the actions set out here require effective steps from different actors at all levels: from global and regional organisations, national and local government, non-governmental and civil society organisations and, above all, local communities and individuals. The specific roles and responsibilities of these different actors cannot and should not be 'blue-printed'; they need to reflect the needs and potentials of different places and times. What is intended here is a framework for action that stimulates these different actors to think about and integrate the relationship between freshwater ecosystems and social security into the decisions that they make regarding the management of these resources.

1. Improve water resources governance through structural institutional reforms

- Develop, strengthen and enforce proper legislation regarding water and land resource rights and entitlements.
- Establish structures for representative decision-making, consensus building and conflict resolution in integrated water resources management.
- Promote the development of an environment in which NGOs and community-based organisations for water and development can be established.
- Develop demand and supply management strategies to better use and conserve water resources.
- Promote integrated planning as an integral part of wider development strategies.
- Maintain and upgrade current water resources and freshwater ecosystems monitoring networks.
- Enhance regional cooperation in water resource management through establishing and strengthening river basin organisations that are representative of all stakeholder interests.

2. Develop new and foster existing partnerships between water resources management organisations

- Foster a learning process based on experiences and best practices worldwide.
- Facilitate a greater sharing of research results and data, at the national level between various natural resources institutions, and at the international level between South-South, North-South, East-West.
- Enhance capabilities through sharing and exchanges between organisations.
- Develop appropriate linkages with private sector water-management organisations.

3. Promote and establish action at community and local levels

- Develop exchanges of experiences in sustainable freshwater ecosystem management between similar resource user groups in different communities.
- Develop processes for mitigating conflicts between competing resource users.
- Promote local participation in planning, implementation and evaluation of projects, and establish links to institutions beyond the local level.
- Build the capacity of local groups to improve resource management and to cope with natural and human-induced variability in temporal and spatial terms.
- Ensure that local freshwater ecosystem management increases sustainable use of resources.
- Legitimise local tenure and resource rights and entitlements and access to resources.

4. Create understanding and awareness about trade-offs, opportunities and flexibility

- Promote a learning approach that leads to an increased awareness of ecosystem functioning and appropriate development alternatives at grassroots, NGO and government levels.
- Define trade-offs, and negotiate effective solutions through stakeholder analysis, taking into account needs of freshwater ecosystems.
- Reduce pressure on freshwater ecosystems by diversifying patterns of resource use and increasing efficiency.

5. Maintain and improve capacity of freshwater ecosystems to provide goods and services

- Rehabilitate inherited degraded freshwater ecosystems.
- Establish socially and environmentally sensitive pricing mechanisms.
- Maintain water quality by preventing polluting inputs into freshwater ecosystems through proper effluent treatment.
- Maintain freshwater biodiversity by monitoring and setting limits to acceptable standards of biodiversity loss.
- Establish integrated catchment management in order to preserve and enhance diversity of habitats and resources and resilience of ecosystems.

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Workshop Report

1. Introduction

The purpose of this report is to provide a summary of the discussions and outputs of the Freshwater Ecosystem Management & Social Security Workshop held in Harare, Zimbabwe, April 13-15, 1999.

This workshop was the first of a series of three interlinked workshops which will form the heart of the consultation process for the Vision for Water and Nature component of the World Water Vision (see Annexes 1 and 2 for description of both processes). The consultations, leading to the creation of a Vision for Water and Nature, are being undertaken by IUCN – The World Conservation Union.

The workshop brought together 23 southern and northern professionals with a wide variety of geographical and technical backgrounds and expertise related to social security issues associated with freshwater ecosystems and water resources management. A full participant list can be found in Annex 3.

The objective of this workshop was to develop a framework vision for Freshwater Ecosystem Management and Social Security, as a part of the Vision for Water and Nature.

As a starting point for debate, a discussion paper[1] was prepared to challenge conventional thinking and propose new key elements for discussion. In order to do this, the paper starts by presenting a conceptual framework, including a definition of what is meant by social security and the societal processes through which it is created. It then discusses, through a series of case studies, freshwater ecosystem management and social security in the modern world. It goes on to look at the future, presenting an analysis of three scenarios developed for the overall World Water Vision. These scenarios indicate the uncertainties the world faces as we enter a new millennium, a circumstance that makes the maintenance of social security systems all the more important. Finally, it considers strategies for the future by first outlining approaches that can address structural issues of institutional processes that underlie water resources-social security relationships, and then considering some adaptation and mitigation strategies that are appropriate for specific challenges.

In addition to this discussion paper, inputs were sought from all participants prior to the workshop to round out the basis for discussion. All participants were invited to submit 300-word statements on the two or three crucial elements to be addressed by a Vision statement on water and social security.

During the workshop, a combination of plenary and smaller working group sessions examining specific topics were used to arrive at the final workshop statement. Additionally, as this is only one part of the overall World Water Vision process, participation from and links to other sectors of the World Water Vision were worked into the proceedings.

At the conclusion, a Final Statement on Freshwater Ecosystems Management and Social Security was produced and discussed. This main output of the workshop will feed into the development process for the Vision for Water and Nature as a whole.

1. Soussan, J., N. Emmel, and C. Howorth. 1999. *Freshwater Ecosystem Management and Social Security*. IUCN – The World Conservation Union, 59 pp.

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2. Workshop Discussion Report

The workshop aimed to facilitate this discussion by adopting a format that combined discussion groups with plenary sessions, in order to maximise the contribution of participants' expertise and their diverse backgrounds. The agenda was developed to allow a free and critical discussion on the institutional processes affecting freshwater ecosystem management and social security. The final agenda can be found in Annex 4.

The Workshop was opened by Ms. Tabeth Matiza Chiuta, representing the host organisation, the IUCN Regional Office for Southern Africa. Duties for chairing the various plenary sessions were shared by Dr. Ger Bergkamp, IUCN Senior Advisor on water resources; Dr. Cristina Espinosa, Global Facilitator of the IUCN Social Policy Programme; and Dr. Atiq Rahman, Director of the Bangladesh Centre for Advanced Studies. Dr. Espinosa noted that IUCN has taken on the task of developing a Vision for Water and Nature because of its core commitment to unite social and environmental agendas, focusing on their common goals.

The work of the first day began with an introduction to the discussion paper by its principal author, Dr. John Soussan, of the Environment Centre of the University of Leeds (UK). In introducing Dr. Soussan, Dr. Bergkamp remarked that one of the main challenges facing water resource managers today is to regain and re-instil in the public at large the sense of mythic awe for water as the root of all life that guided humankind from its earliest days. He suggested that although the water myth has been lost in our modern technological age, by recapturing it in our Vision we will be able to establish change. According to Dr. Bergkamp, only by giving water back its status as the precious commodity that it truly is, and granting it sacred trust, can it be hoped to protect and preserve the sustainability of aquatic ecosystems and resources for their own good and for the goods and services they provide to humankind.

Dr. Soussan picked up the challenge to stretch the analysis beyond conventional approaches in his presentation of the discussion paper, which formed the basis of the three days of discussions. There is little common ground in the literature between the topics of social security and freshwater ecosystems. The two have seldom been discussed in relation to one another before. To make up for this gap, a 'livelihoods approach,' which is effectively the state of the art of the 1990s in social sciences, was superimposed upon more classic examples of aquatic resources management at increasing scales, from the family, community and village out to regions, nations and the global dimension. The result is a novel look at a critical dynamic: how social security is engendered by wise management of an essential resource – water and the ecosystems on which it depends – and how, in return, the sustainability of that resource is enabled once social security is assured.

The first two days were spent in small discussion groups. Each debated a topic of key concern which, when taken collectively, were intended to lead toward the Vision of Freshwater Ecosystem Management and Social Security. These ideas were then discussed in a plenary session where the integration of concepts began to take shape, leading to the final formulation of the Final Statement.

2.1 Group 1. Social security and freshwater ecosystem management at the level of livelihoods

This group examined two questions in pursuing the issue assigned to them:

1. What do we see as the main sources of conflicts and/or social insecurity stemming from current freshwater ecosystem management practices?

The consensus response included issues such as a lack of understanding and knowledge, poor policies and planning, conflicts over rights and entitlements, conflicts for use of the same resource, lack of capacities (knowledge, institutions, finances), competing uses and interests, and poverty.

2. What makes households and communities less vulnerable in terms of access to freshwater resources and social security?

In responding to this question, members of the group identified three overarching issues: peace and security; good assets and access to credit; and maintenance of a resilient ecological system. Other specific issues identified included: sustainable use of the resource base; rights and entitlements/ access to benefits; knowledge and awareness; improved planning systems, decision-making and planning; effective institutions and support organisations; co-management/ participatory management; and strong community.

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The group also provided some ideas that it felt should be considered in the development of a Vision statement. Firstly, in considering the linkages between ecological goods and services and social security, there is considerable lack of understanding and a need to raise awareness. They cautioned that we need to consider very carefully which paradigm we espouse: water as a social and environmental good; or water as a commodity. Market influences in freshwater resource management can be a double-edged sword. We must consider market mechanisms to control distribution versus legal rights and entitlements to determine distribution. A very open market system is not well-buffered for changes at the local level, which makes communities more vulnerable to social insecurity.

We have to consider what trade-offs are acceptable: the ethical value of degrading vs. preserving environment; the value of pristine environments vs. basic human needs; the acceptability of ecosystem loss/how much change is acceptable. All of this demands an understanding of resilience, both social and environmental, and solid indicators of resilience.

The role of the community as a determinant in livelihoods systems is paramount. Communities should, however, not be perceived as uniform units; important differences within communities must be considered, which determine access to and control over water resources. The differences within communities are often based on:

- community divisions related to political, gender, ethnicity, etc.;
- conflicting resource needs and uses;
- empowerment – maintaining current/traditional practices;
- awareness;
- internal structure.

The group also sounded a word of caution regarding maintaining relevance of the Vision by ensuring that it adequately addresses issues of urban as well as rural communities and the North as well as the South.

Finally, the participants noted that it is popular today to emphasise the importance of community-based planning and management but, in so doing, it must be recognised that there are many circumstances which are beyond the control of the community. Examples include: state government decisions; upstream/downstream development; and world commodity markets.

2.2 Group 2. Social security and freshwater ecosystem management related to the interactions between government and civil society

The group began with some discussion around the question of the definition of 'civil society.' It was decided that it was best to work from a broad definition such as that used in the Social Security discussion paper (Soussan). To paraphrase, this is a concept which includes all formal and informal non-state institutions that influence the behaviour of individuals and groups within a society.

This group also conducted its discussions in reference to two pre-set questions:

1. a) What are the constraints that national and local governments face to improve their capacity to govern freshwater ecosystems in more sustainable and equitable ways?

Two clusters of issues were identified by the group. These were:

1) *Policy/Legislative Issues*, which result in inappropriate rules and laws to protect freshwater ecosystems and provide social security. Examples include a lack of policy and laws (i.e. necessary legislative framework unavailable or not appropriate) and aspects of user rights and equal access (i.e. the issue of water scarcity in real terms and/or the problem of distribution).

2) *Capacity Issues*, which prevent application of appropriate rules and laws where they do exist. This issue has resource and education sub-groupings.

- In the area of **resource constraints** would be found finance and funding issues (including limitations of and access to funds); and the lack of inventories of freshwater ecosystems and associated issues (such as lack of methodologies and tools for decision support, insufficient monitoring capacity, data collection and database management).
- Under the **need for better education**, specific examples include non-enforcement of existing laws relating to freshwater ecosystem management, institutional inertia, and decision-making that is responsive to certain interests without regard to balancing conflicting user demands. All of these are, in some measure at least, a result of a lack of awareness or education.

Having examined the constraints that are inhibiting states from undertaking equitable and sustainable freshwater ecosystem management, the group examined the corollary to this question:

1. b) What changes are required for the state to achieve sustainable and equitable Freshwater Ecosystem Management?

There was some discussion as to whether change was actually necessary, or as the question was stated, "Is there really a crisis?" There was strong consensus in the group that change was necessary.

The group considered changes in a fairly broad range of categories (relative to the constraints identified) and developed this further by considering what needs to change and then suggesting how to change it. Without elaborating on the details of the group's discussions, changes were found to be needed in six areas: improved governance; legislative reforms; capacity building; devolution/decentralisation; planning and management strategies; and budgets.

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The group then examined a second area of related enquiry:

2. a) What are the social and environmental implications of water management based on efficiency criteria (cost-efficiency, as defined by water managers)?

From the social implications standpoint it was concluded that efficiency criteria alone will disadvantage the poor and, considering the gender perspective, women more than men, as the latter are generally better integrated into the 'productive' economy. In addition, it was felt that needed large scale water works would not proceed if cost-efficiency were the sole criterion considered. On the environmental side, problems exist with a cost-efficiency approach as well: is it cost-efficient to protect habitat for non-commercial species, for example? Is the 'environment' a user that has to pay for water – or is it the resource base? The 'value' of ecosystems is always minimised in the cost-efficiency equation. On the other hand, if cost-efficiency were the rule, commercial interests would reduce their water use, producing environmental and social benefits.

In summary, the 'productive water first' principle has a negative aspect on women and the poor, as well as on the environment, since the environment is often seen as non-productive.

A corollary of this second question is:

2. b) What role can water pricing play in promoting equitable sharing of limited water resources and conservation?

It was concluded during discussion that water pricing can play both negative and positive roles, depending on how it is instituted. If there is due concern to equity in the distribution, both in terms of needed allocations to the poor and for nature, then water pricing can be positive because it leads to conservation of the resource.

Issues raised during discussion that need to be factored in relate to improved water management, water saving measures, and the application of a pay-as-you-use principle.

Other caveats included in the comments provided by participants include:

- progressive tariffs can promote both equity and sustainability;
- if need and ability to pay are factored into the policy, then it could be positive;
- the value of ecosystems should be taken into consideration;
- bigger users by volume should pay more (sliding scale);
- people will use water more carefully – environmental benefits.

Finally, the group suggested a number of actions that would potentially lead to these goals:

- learn from best practices and successes globally and adapting to local/regional conditions;
- increase awareness through traditional methods and greater use of new communications technologies;
- establish structures, such as river parliaments, for discussion and consensus building and conflict resolution in integrated water resources management;
- create indigenous NGOs for water and development;
- involve the business community as a responsible partner in water resource management;
- build capacity to cope with natural and man-induced variability in temporal and spatial availability of water;
- facilitate greater research sharing on sustainable use of water and freshwater ecosystems (South-South as well as North-South);
- match penalties for infractions with incentives for socially responsible water use practices;
- organise communities to take responsibility to demand greater access to existing resources in a sustainable way.

2.3 Group 3. Towards a vision: Redefining the institutional context

The question presented to this group was:

1. How to bring change into the current institutional context to enhance freshwater ecosystem management and social security?

To motivate debate on this subject, the group Chair, Dr. Atiq Rahman enunciated a simplified Vision and challenged the group to define a realistic set of goals directed toward that idealistic Vision:

Access of good quality water for all people, all ecosystem services, and all ecosystem survival, at all times, and for all resource needs (sectors, communities, agriculture, industry, etc.).

The group concluded that within this idealised Vision, a number of practical goals should be achieved over the next 25 years, including:

- catchment-level integrated water resources management in place at regional levels everywhere, to reduce social vulnerability;
- enhanced equity of social access (considering both temporal and spatial dimensions);
- institutions that are more socially responsive and respective of ecosystem needs, and able to adapt to changing context;
- local delivery, supported by strong national and regional institutions, recognising global conventions;
- conservation leading to more efficient use of water.

To get there however, a base set of terms of reference is needed for what is required for institutions to make this happen.

Institutions should:

- be able to operate in a changing world (resilience);
- be more socially responsive and accountable (equity);
- develop and maintain a greater information flow and more transparency in decision making (openness)
- be capable of incorporating all stakeholders (inclusiveness);
- be provided with adequate resources (capability);
- adopt multi-sectoral and integrated approaches, engendering a willingness among government agencies and governments to work with one another towards truly integrated planning and management;
- create conditions through which social mobilisation can lead to empowerment of the individual and the community to take responsibility and force change in government institutions.

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2.4 Group 4. Towards a vision: Mitigation and adaptation strategies at local and global levels

In the final working group session, participants were challenged to develop a process for change through mitigation and adaptation strategies at local and global levels.

To begin with, the participants examined the trends that act as a backdrop against which change must occur:

- increasing world population;
- increasing urbanisation, leading to an increasing role for regional level management;
- increasing degradation of freshwater ecosystems (biodiversity, quality, quantity);
- increasing pressure on water and land resources;
- replacement of traditional resource users with commercial/non-indigenous users;
- changing climate affecting hydrology;
- increasing local, national and transboundary conflicts over fresh water;
- increasing stakeholder involvement in planning and development;
- environment increasingly seen as a legitimate user of water;
- structural reforms leading to dismantling of bureaucracies;
- increasing awareness of need to maintain forests and rivers for direct goods and services;
- increasing involvement of the private sector in resource use and management (including water).

From these trends, or in recognition of them, the following realistic goals were defined:

- all peoples will enjoy social security, including water and food security, and security in non-material aspects, such as local-level empowerment, social well-being and equity;
- all freshwater ecosystems will be healthy and provide utilitarian goods and services such as drinking water, fish, and recreation, and support non-utilitarian processes and products such as nutrient cycling and biodiversity.

In order to achieve these goals, certain strategies were defined:

- Maintain and improve the capacity of freshwater ecosystems to provide goods and services:
  - rehabilitate inherited degraded freshwater ecosystems;
  - maintain water quality by preventing pollutants from entering freshwater ecosystems through proper effluent treatment;
  - maintain freshwater biodiversity by monitoring and setting limits to acceptable standards of biodiversity loss;
  - establish integrated catchment management in order to preserve and enhance ecotones and diversity of habitats and resources;
  - protect the resilience of ecosystems through riparian zone management, head water maintenance, reforestation, etc.
- Create understanding and awareness of trade-offs, opportunities and flexibility:
  - promote a learning approach that leads to increased awareness of ecosystem functioning and alternatives at grassroots, NGO and government levels;
  - define trade-offs within local circumstances and negotiate effective solutions through stakeholder analysis, taking into account needs of freshwater ecosystems;
  - reduce pressure on freshwater ecosystems by diversifying the types of resource use.
- improve freshwater resources management:
  - develop demand-management strategies to conserve water resources;
  - establish integrated planning as an integral part of a development strategy.
- Promote and establish action at community and local levels:
  - develop exchanges of experiences in sustainable freshwater ecosystems management between similar resource user groups in different communities;
  - promote local participation in planning, implementation and evaluation of projects, and establish links to institutions beyond the local level;
  - build the capacity of local groups for resource management;
  - legitimise local tenure, and resource rights and access to resources.

As a complement to the group work described above, the workshop included a session in which participants were encouraged to present their thoughts on input to the Vision, based on their own experiences. Additionally, the participants heard about the development of and learned the perspectives from other aspects of the Vision, namely Water for People, Water for Food and the Framework for Action, the latter being developed in conjunction with the World Water Council by the Global Water Partnership.

3. Conclusions and Next Steps

The key output from the workshop was the Vision statement, reppearing before the introduction to this Workshop Report. The Final Statement is not meant to be considered as a stand-alone document. Rather, the Vision described therein forms one input into the development of an overall Vision for Water and Nature. It will be brought forward at subsequent workshops and combined with similar visions to be produced on economic and environmental security. this having been said, comments are invited on the Social Security Vision statement to validate its conclusions and to ensure that it has encompassed all relevant issues.

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Annex 1

World Water Vision

Throughout 1999 until March 2000, the World Water Council is developing a **Vision for Water, Life and the Environment in the 21st Century (World Water Vision)** to address the pressing issue of scarcity of freshwater in localised areas, and chart a course toward more sustainable and equitable use of water resources.

It is intended as an intensive consultation exercise, bringing together stakeholders and professionals, both within and outside the water sector, which is meant to take us from where we are today to where we need to be to meet future water needs. This process of study, consultation and promotion aims to:

- *develop knowledge* on what is happening in the water sector, and on trends and developments outside the water sector that will have an impact on future water demand and supply;
- *raise awareness* of water issues among the general population and decision-makers in order to foster the political will and leadership necessary to achieve the Vision;
- *produce a consensus* on a Vision for the year 2025 that is shared by all stakeholders;
- *contribute to a framework for action* with steps to go from vision to action.

The consultations will take place through a number of means:

- *Thematic Panels*: experts consider possible future developments in biotechnology, energy technology, information technology and institutional changes, and their implications for the water sector.
- *Scenarios*: a framework that describes possible futures and their driving forces.
- *Sectors*: professionals discuss strategic water issues in key sectors: Water for Food, Water and Nature, Water for People (supply and sanitation), and others.
- *Regions*: regional stakeholders will discuss and develop a regional vision: a desirable future and how to get there.

In addition, a website has been developed to facilitate broad-based consultations from all interested parties: http://www.watervision.org

Annex 2

Vision for Water and Nature

IUCN-The World Conservation Union has been asked to lead the development of a specific sector vision on **Ecosystems and the Environment (Water and Nature)**. This Vision for Water and Nature will be combined with and contribute to visions of the other sectors, as well as the regional visions addressing the geographically varying issues confronting different parts of the world.

To develop the Vision for Water and Nature, IUCN will call upon the advice of many specialists and interested organisations, not only in the water sector, but in different socio-economic and scientific disciplines that bear upon the use of water.

The key basis for consultations will be three workshops, focussing on the related themes of how management of freshwater and aquatic ecosystems affects **social**, **economic** and **environmental** security. At each workshop, participants will examine, as a starting point for debate, expert opinions captured in discussion papers which are intended to challenge conventional thinking. At the same time, all interested individuals will be invited to examine and offer their comments on these documents via Internet-based discussions. The three scheduled workshops are:

- Freshwater Ecosystem Management & Social Security, April 13-15, 1999, Harare, Zimbabwe
- Freshwater Ecosystem Management & Economic Security, June 9-11, Bangkok, Thailand
- Freshwater Ecosystem Management & Environmental Security, June 22-24, 1999, San José, Costa Rica

The draft Vision for Water and Nature will be submitted at the Stockholm Water Symposium in August 1999 and provision will be made, if required, for a final round of consultations to complete the Sector Vision. It will then be incorporated into the final product of the overall process: an integrated World Water Vision for the 21st century, to be tabled at the 2nd World Water Forum and associated ministerial conference in The Hague in March 2000.

A website has been launched to provide information specifically on the Water and Nature process, post key documents such as the discussion papers and workshop reports for downloading, and provide a forum for input into the consultations (http://www.waterandnature.org)

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Annex 3

Freshwater Ecosystem Management & Social Security Participants

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Annex 4

Freshwater Ecosystem Management & Social Security Workshop Agenda

Harare, Zimbabwe, April 13-15, 1999

Day 1	Tuesday, 13 April, 1999
8:30-9:45	**Opening session** Welcome – T. Matiza-Chiuta, IUCN-ROSA Overview on Vision for Water and Nature and the goals of the meeting – Chair: A. Rahman, Director, Bangladesh Centre for Advanced Studies, and G. Bergkamp, IUCN
9:45-10:15	*Coffee Break*
10:15-10:30	**Presentation of participants and expected outputs of the meeting** – C. Espinosa
10:30-11:00	**Presentation of the discussion paper** – J. Soussan
11:00-12:15	Reaction from the floor – Open
12:15-12:30	**Framework for discussion** – A. Rahman
12:30-14:00	*Lunch*
14:00-15:30	**Discussion Groups** • Group 1. Social security and freshwater ecosystem management at the levels of livelihoods • Group 2. Social security and freshwater ecosystem management related to the interactions between government and civil society
15:30-16:00	*Coffee Break*
16:00-17:00	**Discussion Groups** (continued)

Day 2	Wednesday, 14 April, 1999
8:30-9:45	**Plenary: Group Reports on Day 1** Reactions from the floor
9:45-10:15	*Coffee Break*
10:15-12:30	**Discussion Groups** • Group 3. Towards a vision: Redefining the institutional context • Group 4. Towards a vision: Mitigation and adaptation strategies at local and global levels
12:30-14:00	*Lunch*
14:00-17:00	**Field Trip** (Technical visit to Lake Chivero, hosted by Dr. Moyo, Biological Sciences Dept., University of Zimbabwe)

Day 3	Thursday, 15 April, 1999
8:30-10:00	**Plenary: Group Reports on Day 2** Reactions from the floor
10:00-10:30	*Coffee Break*
10:30-11:15	**Presentation of individual statements,** including: Water for Food view – K. Frenken Water for People view – G. Keast
11:15-11:30	**Water Resources Management in Southern Africa: Enhancing Environmental Sustainability** – T. Matiza
11:30-11:45	**GWP: Framework for Action** – A. Bullock
11:45-12:15	**Gender Issues** – C. Espinosa
12:30-14:00	*Lunch*
14:00-16:00	**Plenary** – A. Rahman/G. Bergkamp Preparation of a statement on the contribution of the workshop to the Vision for Water and Nature (= linkages among Water, Ecosystems, Social Security)
16:00	**Closing**

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Freshwater Ecosystem Management & Economic Security

Discussion Paper

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A framework paper prepared for presentation at an IUCN Workshop of the World Water Council, Bangkok, June, 1999.
The authors would like to thank David Pearce and Ger Bergkamp for their assistance in the undertaking of this project. We would also like to thank the three peer reviewers and Ariel Dinar for their comments on an earlier draft of the paper. Comments please to Professor Timothy Swanson, Department of Economics and CSERGE, University College London, Gower Street, London WC1E 6BT. (Tim.Swanson@ucl.ac.uk)

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1. Introduction

A freshwater ecosystem links all of the users within the economic and natural systems dependent on it. Freshwater resources also provide a flow of essential services to both economic activities and natural values. It is essential to manage freshwater ecosystems in order to provide for the continuing viability of both the economic and natural systems. This paper will first identify the linkages between freshwater ecosystems and economic systems, and the potential for conflicts. It then analyses how ecosystems provide specially complex management problems, and how society could improve management structures so as to better manage the myriad of human and natural linkages embedded within this system. Section 2 defines freshwater ecosystems in terms of their economic functions, and defines economic systems in terms of impacts on freshwater ecosystems. Section 3 sketches the general nature of the difficulties associated with managing complex and non-compact ecosystems. Section 4 then reviews some policies for addressing problems of freshwater ecosystem management.

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2. Freshwater ecosystems in economic terms and economic systems in freshwater terms

2.1 Freshwater ecosystems in economic terms

2.1.1 The goods and services provided by freshwater ecosystems with associated values

Freshwater ecosystems are among the Earth's most productive ecosystems. They include a variety of environments such as rivers, lakes, marshes, swamps, canals and reservoirs, and provide a number of goods and services to local, national, regional and global economies. The agriculture, tourism, fisheries, forestry and construction industries benefit both directly and indirectly from wetlands. Goods derived from freshwater ecosystems include fish, timber and fuel, wildlife, fertile land and, of course, water. These, along with services such as transport, recreation and scientific study, are examples of direct uses of freshwater ecosystems. Indirect uses include storm protection, sediment and pollution retention, nutrient retention, evaporation and preservation (archaeological). Through these goods and services, freshwater ecosystems provide people with benefits. The intrinsic value people place on freshwater ecosystems is linked to their aesthetic, cultural and heritage significance. For instance, many value Victoria Falls in southern Africa regardless of whether they will ever visit, view or in any way 'use' the Falls. Figures 1 and 2 summarise the total economic value of freshwater ecosystems and demonstrate the relationship of various benefits.

2.1.2 Private goods and public goods: complex linkages between users

The goods and services provided by freshwater ecosystems can be viewed as either public or private goods. The nature of a good determines how it best can be managed, and the institutional structures required.

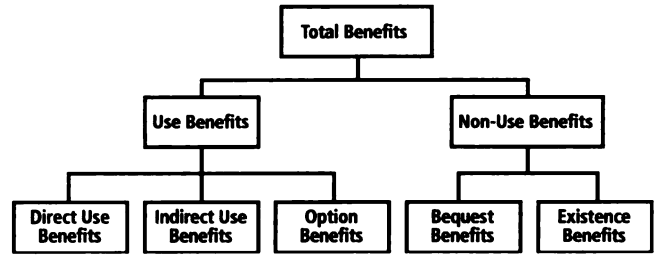
Public goods are goods and services whose provision is 'non-excludable' and 'non-divisible.' When public goods are provided, anyone can benefit from them without reducing their availability to others. A classic example of an environmental public good is the water purification service of a freshwater ecosystem. Many quality-related facets of goods and services from freshwater ecosystems are public goods. These include water quality, storage and purification, groundwater recharge, flood control, storm protection, nutrient retention, and micro-climate and shore stabilisation. Some quantity-related aspects of these ecosystems may also be public goods since consumption of the good is affected to some extent; such resource use is considered non-exclusive, but rival.

Figure 1 Wetland Economic Benefits

DIRECT VALUES	INDIRECT VALUES	OPTION VALUES	NON-USE VALUES
Fishing	Water quality	Possible future pharmaceuticals, Agricultural and industrial applications of biological resources, Leisure use of ecosystems, Water-based developments ... etc.	Intrinsic existence, Cultural, aesthetic, heritage and bequest significance ... etc.
Fuelwood	Water flow		
Building poles	Water storage		
Thatch	Water purification		
Hunting	Groundwater recharge		
Wild foods	Flood control		
Medicines	Storm protection		
Agriculture	Nutrient retention		
Pasture	Microclimate		
Transport	Shore stabilisation		
Recreation	... etc.		
... etc.			

Source: Emerton, 1999

Figure 2 Depiction of Benefits



Private goods, on the other hand, are goods and services whose provision is 'excludable' and 'divisible.' Private goods are held exclusively by individuals, and their use reduces the supply available to others. The linkages between users of private goods are confined to market-based transactions. Many of the quantity-related facets of the flows of goods and services of freshwater ecosystems are of this nature.

Whether the nature of a good or service of a freshwater ecosystem is predominantly public or private determines how it can most efficiently be managed. Market-based processes are best suited to managing private good aspects of freshwater ecosystems because markets provide economic incentives to individual decision-makers. Examples include water markets in western Canada and the United States, fish markets in Southeast Asia, and fuelwood or peat sales in Africa or South America.

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However, many goods and services produced by freshwater ecosystems are more 'public' in nature, and public sector involvement is required in the management of these resources. These are services that flow broadly or generally to society (such as nutrient fixing or biodiversity conservation) or even to other species (such as waterfowl). The private sector does not have incentives to manage public good resources. The task of effective public intervention is to ensure the conservation of such complex flows and functions. This is a fundamental challenge in ecosystem management. Balancing public and private objectives in the management of freshwater ecosystems is the subject of this paper.

Finally, it is also important to note that fresh water is a foundational good: one that is a prerequisite for the existence of many other flows or values. For example, fresh water is an essential requirement for most forms of agriculture, industry and even human existence. Its non-substitutable nature makes it a focal point in many areas of conflict and social concern.

2.2 Economic systems and impacts on fresh water ecosystems

2.2.1 The quantity of freshwater and the impacts of economic systems

Freshwater ecosystems and the goods they provide are essential to both environmental and socio-economic systems. One key good provided by freshwater ecosystems is water. Water is important to humans for direct consumption, for irrigation, for livestock and for industrial use (to name but a few uses). Water is also important to sustain biodiversity and natural habitats. As the human population increases, demand for water increases. Increased use by humans implies reduced supply for biodiversity. Withdrawal of water from freshwater ecosystems affects the ability of ecosystems to provide many of the goods and services described in section 3.1.1.

There are, of course, many conflicts between people over freshwater resources, as well. Conflict results as much from distribution problems as from scarcity per se. If current levels of runoff were evenly distributed around the world, 8,000 m^3 of water per person per year would be available. Water stress is usually limited to situations where renewable supply per annum is less than 2,000 m^3. Thus, globally there appears to be sufficient freshwater for human needs (Falkenmark and Lindh, 1993). But freshwater resources are not distributed evenly across space and time. Table 1 shows differences in per capita availability of water between continents.

Table 1 Continental per capita Freshwater Availability

Region	Annual internal renewable water resources m^3/yr per capita 1990
World	7,690
Oceania	75,960
North and Central America	16,260
USSR	15,220
Africa	6,460
Europe	4,660
Asia	3,370

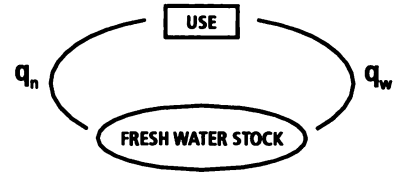
Source: Gleick, 1993

Table 2 Populations with Access to Safe Drinking Water by Region, 1980 and 1990 (%)

	Urban		Rural	
Region	1980	1990	1980	1990
Africa	83	87	33	42
Latin America and the Caribbean	82	87	47	62
Asia and the Pacific	73	77	28	67
Middle East	95	100	51	56
Total these regions	77	82	30	63

Source: Gleick, 1993: 188

Figure 3 The Relationship between the Ecosystem and the Economic System



Large variations also exist at the national, regional and local levels. For instance, while Africa has annual renewable freshwater of 6,460 m^3/year per capita, 30 per cent of total runoff comes from the Congo River basin. At the national level, Somalia has only 1,520 m^3 renewable freshwater resources per capita per year. Spatial variations are compounded by seasonal variations in rainfall and hours of sunlight. In India, for example, rainfall is concentrated in the few weeks of the monsoon. Such natural variation can help to maintain biodiversity in terms of richness in ecosystems, species and genes, but creates pressures for human societies. The reactions of these societies can have very serious negative economic and ecological impacts.

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2.2.2 The quality of fresh water and the impacts of economic systems

Economic activities affect the quality, as well as the quantity, of goods and services flowing from freshwater ecosystems. Pollution reduces the amount of fresh water available for both humans and natural systems. Polluted water is a major cause of illness (80 per cent of illness is water-related) and results in the serious disturbance of many aquatic ecosystems (Falkenmark and Lindh, 1993).

The Figure 3 illustrates how the flow of fresh water available for natural and economic systems depends on both its quality (a function of the quantity of waste it contains – qw) and its quantity (a function of the amount of water extracted – qn). Fresh water, by definition contains low concentrations of contaminants. As water is extracted, the concentration of waste to water increases, and water quality declines.

The definition of 'freshwater' availability must, however, depend in part on the use to which it will be put. Drinking water requires a higher quality than industrial or recreational use, and the availability of drinking water is affected by low concentrations of pollution (Nash, 1993). Access to safe drinking water in developing countries is shown in Table 2. This indicates that the stock of fresh water that is available depends not only on the uses to which it is being put, but also on the many uses that are possible. It is the interaction of uses and potential uses within the system that must be managed.

2.3 The systemic nature of freshwater resources

The above examples describe freshwater ecosystems as a stock of both water and its 'freshness,' or cleanliness; however, one of the most important attributes of a freshwater ecosystem is often its flowing nature. It passes through many different areas, activities and lives, and links all of these various uses and activities by reason of its own passage.

For example, there is a close interdependence among water uses in the same river basin and all of them are, to a certain extent, mutually interfering. The property of mutually interfering usage implies that the withdrawal, consumption and return flows by one user are likely to affect the quality, quantity and timing of supply for other users downstream, making all the uses of the water in a river basin interdependent.

Moreover, in a river basin setting, both positive and negative externalities usually have their effects in one direction only, propagating from upstream to downstream users. This unidirectional feature of externalities has a distributional dimension, which implies that the resolution of water-related conflicts through negotiation or mutual control of external effects that work reciprocally is generally ruled out. For these reasons, the river basin is an ideal unit of analysis to deal with the problem of most water-related externalities, and it is generally assumed that most such systems are best addressed by analysing the river basin as a single unit (Dourojeanni, 1999).

2.4 Conclusion – Links between natural and economic systems

The freshwater ecosystem is the place where many economic activities interact. This is because changes in use in one location affect the quality and quantity of fresh water available in all other parts of the ecosystem. It is also the case that these economic activities are able to accumulate and crowd out other uses of the system. This means that the system provides the natural base within which many interacting economic activities occur, and is also a site of basic conflict between economic activities and natural services. The objective of freshwater management is to resolve these conflicts between economic activities, while providing for the maintenance of the natural services.

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3. Problems in managing freshwater ecosystems

The main barriers to the successful management of freshwater resources are:

- the complexity of interactions and linkages;
- the multiplicity of boundaries;
- the difficulty of valuing and maintaining natural services.

The establishment of a management regime accepted by all users is a complex process that requires extensive negotiation over the distribution of costs and benefits. However, until adequate management is achieved, society will continue to allocate the goods and services of freshwater ecosystems to inappropriate uses. It is often the case that the public goods provided by these systems are disproportionately impacted by inadequate management.

3.1 Basic principles

This section looks at these three main difficulties of freshwater ecosystem management. The key point is that the allocation of natural resources tends to be inefficient in the absence of effective management. The problems of inadequate management stem from the complexities of interaction between users, and the non-compactness of the system. These difficulties lead to predictable costs and inefficiencies in water management. One of the most predictable and important results is the loss of undervalued natural systems and services – the public goods of freshwater ecosystems.

3.1.1 Basics of misallocation of resources

The use of freshwater ecosystems for one purpose will almost always reduce the available flows of goods and services for other users or purposes. Resource misallocation arises in the absence of institutions that balance all aspects/values of freshwater ecosystems, and then allocate the resource accordingly. When an individual or firm makes use of the ecosystem without being made to take account of the effects of its water use on others, an external cost or 'externality' is said to result. The failure to take into account the costs of a use to others will necessarily result in a misallocation of resources toward that activity.

When externalities exist, individuals do not consider the impact of private production decisions on other users of the ecosystem. As a result, the individual acting independently tends to use more water than is 'socially optimal.' For example, a farmer receiving subsidised irrigation pays a cost for water which is below the opportunity cost of that water (the value of that water in a more socially beneficial use). As a result, the farmer will consume too much water, and other users will be deprived of their shares. This misallocation of the freshwater resource is a social harm, resulting from the absence of management institutions to balance and allocate freshwater resources correctly.

3.1.2 Management institutions for freshwater ecosystems

A management institution should perform certain tasks to restrict and reallocate the use of water resources. A limit on aggregate use, and a mechanism for allocating resources between competing uses, need to be established. This requires information on: (a) the stock and flow of the resource, (b) estimation of optimal allocations to different uses and users (including both public and private), and (c) monitoring and enforcement of this distribution of rights over resource use.

The optimal aggregate rate of use, i.e. the level and rate of use that maximise social welfare, must be determined. The water available at any point in the hydrological system varies over time. therefore, it is essential that the rate of flow of water is considered in order to ensure that the rate of extraction does not exceed the rate of input. Different rates of use must be taken into account; for example, industrial users tend to have relatively constant water demand throughout the year, while use for irrigation will be concentrated in the dry months.

When the optimal level of aggregate use has been set, the allocation of use rights should be determined. The fundamental problem in resource management is for users to agree on how a resource should be allocated to reach a socially optimal situation. The allocation of resources is difficult because of the high level of heterogeneity of uses and users within these ecosystems.

3.1.3 The simplest case

The simplest case is where the external effects experienced by each user are identical and reciprocal. In this case, all users have an equivalent incentive to improve the situation through self-motivated cooperation. Where each party undertakes the same kind of restrictions, the benefits are shared symmetrically and equally. This built-in reciprocity within the resource system makes cooperation much easier to achieve.

Take the case of an aquifer that supplies water to a group of identical users who rely on it for identical uses. In the case where all users are at the same point in the hydrological system, require water for the same purpose and are under the same jurisdictional control, each faces identical incentives to cooperate. If one player considers reneging on their undertaking to manage water use, the threat of retaliation by other

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users at a later stage will be enough to make that person cooperate, and the agreement becomes self-enforcing. Since all stand to gain from cooperation and will be punished in the long run for misbehaviour, the gains from contracting far outweigh the costs and an agreement should result (Barrett, 1990). Thus, agreement is easiest where users are at the same point in the system, have the same uses, and are under the same jurisdiction. Box 1 gives some examples of agreements reached over water usage.

Table 3 Differences in Water Users and Uses

User	Quantity-related uses	Quality-related uses
Recreational	Boating, Swimming	Oil, General
Domestic	Drinking, Washing	Sewage
Agricultural	Irrigation	Pesticides, Fertilisers
Industrial	Consumption, Energy	Chemicals
Forestry	Trees	Soil, Silt
Fishing	Fish	General Waste
Societal	Aesthetics, Wildlife, Wetlands	Waste Sink

Box 1 Water Users

Examples of Contracting for Water Management

- **While the Mississippi basin crosses many state boundaries, its three tributaries supply a much smaller area. External effects of water use are unidirectional between users. Users of the Lower Mississippi are affected by pollutants from upstream Cincinnati users on the Ohio. Cincinnati users are not affected by the uses of citizens of Memphis. The simple nature of this interaction resulted in agreements, even before the Environmental Protection Act. The "Ohio River Compact gave downriver residents certain rights with respect to upriver pollution."**

Source: Anderson and Hill, 1997

- **Water Users Associations are common in areas where there are a large number of irrigators who share water resources. In Bali, Subaks developed rules to control both the amount of water individuals could extract and the financial and labour contributions that users should make to maintain water systems. Such a decentralised organisation requires a "cohesive social structure that discourages any overt conflict" to effectively ensure that the private and social marginal cost curves converge. The success of the organisation in terms of efficiency of use is unclear. However, the organisational structure has been sustained over time, "providing users with a longer time horizon to increase the payoffs to cooperation."**

Source: Dinar et al., 1997a

The group of users of a system seldom satisfies the requirements of same point, same use, and same jurisdiction. Instead, there is some degree of heterogeneity between parties. Whatever their nature, differences between users increases the range of interests and thus demands. The process of bargaining is intended to allow these demands to be made consistent through mutual compromise and long-term benefits.

3.2 Complexity in freshwater allocation

3.2.1 Heterogeneity in users and uses

There are a large number of possible forms of interaction to consider when identifying the most efficient combination of uses of a freshwater ecosystem. Industry will use freshwater ecosystems both for production (quantity) and for dumping waste (quality). Individuals sharing the same water resource may require it for drinking and recreation. Society may value the same stock of fresh water for public uses such as wildlife or biodiversity. Table 3 presents a number of water uses and users.

Cross-effects between uses are not symmetrical, and location and time are important variables. Asymmetrical conflicts commonly occur between upstream and downstream users. For example, it is unlikely that a recreational use such as swimming will significantly affect a downstream use such as irrigation. The reverse situation, when the water is first used for irrigation, might have serious effects on downstream recreational uses.

Users affect both users in the same and in competing sectors, creating competition for resources both within and between sectors. The high level of water consumption by irrigation in many arid and semi-arid countries has resulted in a structure of water rights that favours the agricultural and rural sectors. As the urban population grows, and demand from households and industry expands, pressure on the resource increases. Conflicts between agricultural, urban and industrial sectors continue to escalate in many parts of the world.

These complexities in the linkages and conflicts between activities render a simple solution to freshwater management problems infeasible. Individuals and industries do not see the potential for reciprocity in their relations with one another, only the potential for conflicts. Determining the wide range of impacts of some activities (such as toxic waste disposal or pesticide use) is virtually impossible. The impacts and interactions span wide areas in time, space and economic sectors. It is this complexity that, in the first instance, renders freshwater management problematic.

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3.2.2 Multiple governance units/boundaries

The second key aspect of freshwater management problems is their non-compactness: they are diffuse and fugacious systems, incompatible with ready compartmentalisation. For this reason, freshwater ecosystems usually cross a number of management boundaries. Consequently, users and uses at different points in the system are under different jurisdictional control. This means that the complexity of interactions and conflicts is translated into a matter of intergovernmental negotiations, adding another layer of complexity to an already difficult problem.

For example, conflict between the national government of Canada and the province of British Columbia prevented the United States and Canada from signing the Columbia River Treaty "despite 'their mutual interest in developing hydropower and flood control facilities on the Columbia." A major factor was British Columbia's desire to realise the benefits from storing water and producing hydroelectric power. The Canadian government, however, evaluated the project at the basin level, and confirmed the benefits to all parties concerned of installing the power plant over the US border (Barrett, 1993).

Issues relating to boundaries are a challenge in regulating freshwater ecosystem resources. If freshwater ecosystems adhered to delineated zones, defining management responsibilities and access rights would be straightforward. Farmers could simply be allowed to use water extracted from their land, countries could use water that flows within national boundaries, and so on. A single regulatory institution could manage the freshwater ecosystem to maximise the welfare of users.

In reality, freshwater ecosystems span many political and bureaucratic boundaries. It is rare that a single management institution has responsibility for a whole ecosystem. Furthermore, responsibilities for the diverse range of goods the freshwater ecosystems provide are spread across a multitude of private and public sectors. Box 2 describes some types of boundaries and outlines how freshwater ecosystems cross them.

It is difficult for institutions to identify and monitor impacts on users who they do not manage. Management units act independently, and have incentives to maximise the welfare of their own members. These institutions may be unaware of the activities of other users of the ecosystem, especially with regard to impacts on the less observable public good functions of such systems, such as the support of biodiversity. Given that these services are spread across many governmental units, the incentive to manage them is dissipated across these units. In not accounting for these functions, management institutions are unable to incorporate the full costs and benefits of their users' actions, and are therefore unable to identify the most efficient allocation of freshwater ecosystem resources.

Box 2

Incompatibility Between Ecosystems and Management Institutions

Water resources cross management boundaries at every level:

1. Land Boundaries

At the local level, water crosses land boundaries (e.g. rivers are shared by neighbours, groundwater aquifers lie under more than one farm). As a result users and uses interact; e.g., the disposal of waste in a river by one user will affect the quantity of clean water available to the neighbour; irrigation will affect the flow of water available downstream.

2. Local Government Boundaries

At the local government level, regions may depend on the same aquifer (e.g. pumping of the Edwards Aquifer by users in one state, say Arizona, affects the water available to users across the state boundary).

3. National Boundaries

At the international level, different countries often rely on the same water resource. There are over two hundred international river basins. The Niger River flows through ten countries. Roughly 65 per cent of total land area in Asia is included in some international river basin.

Source: Anderson and Hill, 1997

Monitoring and enforcement is a sine qua non – an essential condition – for the existence of a concrete and effective management institution. Parties are able to continue to exploit resources in an unrestricted fashion, if non-conforming conduct is not observed and punished. This is a problem particularly where the resources or systems (and their flows) cross international boundaries.

The lack of universal agreement on the legal rules for ownership rights undermines the development of effective management institutions. While each jurisdiction may have rules by which it abides, these laws differ between nations, states and cultures. When two parties are in conflict, there is no clear way to determine the equitable, acceptable allocation of ownership rights in the absence of a common set of principles. The failure to agree on such common principles prevents the attainment of cooperative outcomes (see Box 3).

This problem has been addressed recently at the international level. The Watercourses Convention, adopted in 1997 by the UN General Assembly, requires that international watercourses must be managed by agreement amongst riparian states. The Convention requires that use of international watercourses must be determined in an 'equitable and reasonable manner,' but it is left to the agreement of the individual users to define what kind and level of use is equitable. If a dispute cannot be resolved, even after 'due diligence' has been exercised, then the convention outlines 'residual rules' for the management of the resource. But there is little guidance available for nations on how to come to a mutually beneficial agreement (Hey, 1998).

For a proposed agreement to be credible, monitoring is required – to ensure that parties follow the rules and to punish if they do not. At the local level, this can take the form of communities designating individuals to monitor the activities of users. One such example is provided in Box 4. It should be noted that the identification of a suitable monitor can be extremely difficult.

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Box 3 River Lauca

River Lauca: Failure to Enforce International Law

The River Lauca begins in northern Chile and crosses the Bolivian border to enter Lake Coipasa. In 1939, plans by Chile to increase water use for irrigation in the upstream reaches of the river were opposed by Bolivia, who feared that water supply would be reduced. A joint commission was established to assess the effects of the proposed plan, and found that no harm would be caused to Bolivia. Bolivia has contested the decision, and 15 years later diplomatic relations between Bolivia and Chile have ceased. Failure to abide by the decisions of the international body and the political need to not lose face prevented cooperation and negotiation.

Source: Lee, 1995: 545

Box 4 Spain

Huerta Irrigation Systems

Near the city of Valencia, in Spain, local communities manage clearly delineated irrigated areas, called huertas. The rules for the management of water developed 550-1000 years ago. Because the rules are flexible, "farmers have continued to meet with others sharing the same canals for the purpose of specifying and revising the rules that they use, selecting officials, and determining fines and assessments." (Ostrom, 1990: 69)

Careful monitoring ensures that only the assigned allocations of water are being used by farmers. Since scarcity of water renders the temptation to defect on the agreement very high, 'ditch-riders' are paid to oversee the activities of water users. The monitors are accountable to the governing body. Punishment for those who do not comply with the rules includes fines and humiliation of public disapproval. The success of local monitoring is reflected in the infraction rate of only 0.008. The monitoring of small-scale schemes is difficult to replicate in larger schemes, as the time and labour requirements are high.

Source: Ostrom, 1990

3.3 Valuing and maintaining natural services

The third key facet of the freshwater management problem is the undervaluation of important natural services from the system. Freshwater ecosystems provide a stream of services of a 'public' nature that are often undervalued and unsupplied simply because they are difficult to identify and quantify. The above discussion has covered some of the direct values of ecosystems; for example, values associated with wildlife, fisheries, and agricultural resources. Ecosystems, however, provide a large number of important services that are far more indirect, even though equally important. Table 4 demonstrates the direct and indirect values of a wetland in Guatemala.

Table 4 Wetland Values: Petexbatun, Guatemala

Components	Direct	Indirect	Non-use
Forest resources	●●●		
Wildlife resources	●		
Fisheries	●●		
Forage resources	●●		
Agricultural resources	●●		
Water supply	●●●		
Functions			
Groundwater recharge/discharge		●	
Flood and flow control		●●●	
Shoreline/bank stabilisation		●●●	
Sediment retention		●●●	
Nutrient retention		●/●●	
Recreation and tourism		●●●	
Water transport		●●●	
Attributes			
Biological diversity	●●	●●	●●
Uniqueness to culture/heritage			●

Source: Barbier, 1989

Notes: ● = low ●● = medium ●●● = high

There is clearly a large number and diversity of direct and indirect values provided by natural ecosystems. Shoreline stabilisation, sediment/nutrient retention, and biological diversity maintenance are a few of the key indirect values supplied by a wetland. When the direct uses of freshwater are the only ones considered in the management system, the indirect uses are driven into decline.

Moreover, the value of the indirect benefits that are often overlooked can be significant, and may even dwarf the more tangible benefits, which are exploited on a commercial basis. For example, a social cost-benefit analysis of a forest in Cameroon has demonstrated that, when attempts are made to derive values for services far removed from the market place, these indirect values can outweigh the direct-use values. Preservation of the rainforest, by maintaining watershed protection services, provided economic benefits to a downstream fishery that were larger than the value of foregone harvesting of timber. Combined with other less-tangible values, such as control of flood risk, maintenance of soil fertility and genetic diversity, and sustained forest use, the preservation of the forest was by far the optimal use of the resource (Ruitenbeek, 1989).

It is essential that valuation exercises are undertaken that attempt to incorporate these diverse uses and values into the management system. A recent study of the Po River Valley aquifer (that has long supplied Milanese households with their drinking water) found that the people of Milan valued these indirect uses far in excess of the value of the agricultural products being grown in that valley. They were willing to pay significant amounts to prevent the contamination of the system from agricultural chemicals being used in the Po Valley (Swanson and Vighi, 1998).

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These services are important and societies are willing to pay for them. An essential component of the freshwater management problem is to provide the mechanism through which these preferences may be expressed, and these services preserved.

3.4 The costs of resource misallocation

This section illustrates how people attempt to distinguish themselves from others in the process of negotiation, in order to claim individually a greater share of the societal benefits from joint management. The wide variety of rules of entitlement, and the ways in which they are used to create individual claims of entitlement, illustrate problems in attempting to create effective management institutions when many pre-existing claims are challenged.

3.4.1 Inequitable allocations

Water users may justify claims to freshwater ecosystem goods based on historical patterns of use rather than a balance of benefits. The fact that a group of users was using the ecosystem first is often used to justify their right to maintained flow, or to compensation if the resource is reallocated. This is called prior appropriation in time. When sharing a freshwater ecosystem, increased resource use upstream reduces the amount of water available to downstream users. This is called prior appropriation in use.

Imperial Valley, east of San Diego, USA, has less than three inches of annual rainfall. In the early 1900s, most of the flow of the Colorado River was allocated to this area, as there were no competing uses at that time. Currently, "the 150,000 people in the Imperial Irrigation District (IID) are entitled to six times more water from the Colorado than the 16 million people of the Metropolitan Water District." Due to the early appropriation of water rights, IID can now offer to sell approximately 200,000 acre-feet of water a year to San Diego. Farmers capture very large resource rents from the sale of water to the municipality (The Economist, 1992).

3.4.2 Rent seeking in making claims

The gains from prior appropriation of freshwater ecosystem goods, in use and time, produce incentives to maximise allocation early on in the allocation process. By engaging in prospective purchases, users increase the scarcity of the resource, and create a more complex environment within which management institutions must be negotiated and implemented.

For example, the Murray Darling Basin Commission was established in south eastern Australia to manage the dwindling capacity of the river basin to provide water. Reform took a piecemeal approach and different states within the basin introduced measures at different times. The lack of a comprehensive framework for water management meant that different regions provided different packages of water rights definitions and values. Some irrigators were able to exploit water they did not need, but which was not subject to regulation. This water then became a valuable asset under new ownership rules.

3.4.3 Misallocation and loss of freshwater ecosystem goods

The costs of continuing misallocation lie in ongoing inequitable and inefficient distributions of freshwater resources. One of the clearest examples of these social costs is the loss of the public goods flowing from freshwater ecosystems. For example, many countries have attempted to lower groundwater tables in recent decades to improve conditions for agricultural production. The hydrological changes have 'desiccated' natural ecosystems. The drop in soil moisture causes species adapted to moist environments to disappear and biodiversity to be reduced. The loss of biodiversity is a cost to society that should be incorporated into decisions about resource allocation. Similarly, the capacity of forests to sequester carbon should be valued and incorporated into land-use and timber harvesting decisions.

There is frequently conflict over water between uses for preservation of wildlife and irrigation in the Central Valley Project (CVP) in California. In 1992, the CVP, which carries one-third of total irrigation water to farms in the San Joaquin Valley, was suspended to prevent the water level in the spawning ground of the chinook salmon from falling to levels so low that the fish would overheat and die. Provision of irrigation water dropped from 8 million to 2 million acre-feet in 1992 to protect the fish.

3.5 Problems in freshwater ecosystem management – conclusion

The underlying problem of freshwater ecosystem management is the need to develop management institutions that span the range of uses and users that are connected in freshwater ecosystems. Linkages between sectors, between different uses within sectors, and between private uses and public uses, must be resolved to move toward first-best resource allocation.

Institutional complexity derives from two sources. First, the freshwater ecosystem itself spans a wide range of jurisdictions and their concomitant management rules and structures. Second, movement toward joint management structures must take place in the context of prior claims and expectations generated by pre-existing rules and institutions. These complexities rule out simplistic solutions to freshwater ecosystem management. The solutions to freshwater ecosystem management must be found in the continuing evolution of institutions across pre-existing boundaries, taking into account linkages that occur across a wide-ranging ecosystem. Management must ensure that the public-good services of ecosystems are not neglected in favour of distributing usufruct rights to more vocal users.

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4. Strategies for addressing the management problem

This section considers a number of solutions. The difficulties with building the institutions needed to implement these solutions are illustrated by reference to various institutional alternatives (pricing, markets, regulation). No simple institutional solution concept is available for the management of complex systems. What is required is the evolution of more complex and wide-ranging institutions for societal cooperation.

4.1 Economic instruments and complexity

The management regime, which is considered optimal from a theoretical perspective, may not be one which is easily implemented due to the great number and diversity of the freshwater ecosystem users and uses. As a result, most economic instruments are constructed to manage a simplified environment. This implies that changes in freshwater ecosystem use and allocation will provide a step toward a more cooperative solution rather than to the theoretically optimal situation.

Nevertheless, the implementation of an allocation mechanism can significantly affect the behaviour of users and improve the efficiency of resource use. To effectively influence behaviour, a water allocation system should: (a) be flexible in the allocation of existing water supplies, (b) provide security of tenure for established users whether or not these users are confronted with the real opportunity cost of the resource, (c) incorporate the opportunity costs of resources into decision-making, (d) ensure the predictability of the outcome of the process, (e) be equitable and fair, and (f) reflect public values (Howe, Schurmeier and Shaw, 1986).

The allocation mechanism should be sufficiently flexible to allow the allocation of freshwater ecosystem goods to adapt to fluctuations in demand and supply. The right to freshwater ecosystem resources and the resources themselves must be exchangeable to allow resources to move to activities that have the highest marginal value in use. Users should be in no doubt as to the present and future validity of their allocations.

An effective instrument for resource reallocation must internalise externalities. Institutions should value goods at their opportunity cost in order for them to be allocated to their most valuable use. Prices must approximate the value of each resource in alternative uses. For this reason, the valuation of the public goods elements of these services is crucial (Swanson, Mourato and Day, 1999).

Predictability is important to encourage long-term investment in resources. While rights must be transferable to allow flexibility, if users are not certain of the outcome of a water allocation process and do not fully understand the rules of the game, they will not invest in the system or in the resource.

Equity is important for enforceability in complex systems. If the allocation of goods is not perceived as 'fair,' i.e. it does not make all consumers at least as well off as they were before, then it is unlikely to be accepted. Given the complex links within the freshwater ecosystems and the difficulty of monitoring and enforcement, the absence of acceptability will prevent conformance.

4.1.1 Rights and entitlements

One method to internalise externalities is to assign property rights over components of the freshwater ecosystem. When individuals own a right to a share of the resource, they have improved incentives to exploit that resource more carefully to ensure future access. Once the socially optimal level of resource use has been determined, the allocation of rights should follow. If a system of property rights is to be accepted, the historical pattern of appropriation must be taken into account. To ensure equity, users should be able to continue to use the freshwater ecosystem or be compensated.

For example, in Japan, the Old River Law of 1896 formalised the allocation of water. Customary rights were recognised by this law, ensuring that local custom was respected and an equitable allocation of water use maintained. However, modifications to these rights will be essential to ensure long-term economic efficiency. For example, many customary rights dictate the kind of equipment that can be used rather than the volume of water to be extracted. Moreover, because customary rights differ between localities, it will be necessary to resolve conflicts between upstream and downstream users through an agreed set of rules as competition for water increases (Swanson, Mourato and Day, 1999).

It should be noted that the mobility of water presents a problem in the definition and enforcement of property rights. Water is almost never fully consumed by any particular user, but is used and reused by many different users as it flows from the watershed to the sea. This implies that water rights are not exclusive, but overlap.

Careful and transparent identification of entitlements and the responsibilities associated with these entitlements is essential. However, some caution is warranted in identifying the conditions of entitlements. For instance, the fact that the failure "to use a water right for a set number of years can lead to the right's forfeiture or abandonment" is intended to prevent players from claiming rights speculatively (Anderson and Hill, 1997). In reality, the limit may reduce the time horizon of the holder and encourage the holder to use water simply to ensure continued eligibility. However, if conditions are not imposed, resource use remains below the social optimum.

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Box 5

The Murray Darling Basin: Federated Water Markets

The Murray Darling Basin in southeastern Australia separates New South Wales from Victoria. As the annual diversion of water from the basin has increased, the capacity of the area to sustainably provide water has decreased. Historically, the owners of land had been able to draw an unlimited supply of water for irrigation and this had allowed the huge increase in demand, with no incentive for water conservation or prevention of waste. By "the 1980s, it was widely acknowledged that the system was suffering from overcommitment to water supplies, waterlogging and rising salinity levels in soils and streams, declining land and water quality, and a significant loss of natural habitat."

In 1981, volumetric allocations were introduced on the Murray River, and were then adopted in New South Wales, limiting the amount of water that any user could withdraw. Permanent intra-regional trading was gradually introduced. As confidence in the system has increased, the number of permanent water transfers has risen rapidly. Temporary water transfers were also introduced, and have been successful in allocating water efficiently. Prices were allowed to fluctuate in line with the scarcity value of water in drought years. For instance, in the drought years of 1994 and 1995, annual water rights cost A$70 per megalitre, compared with A$4 per megalitre several years before.

However, the above incremental approach and the lack of a comprehensive framework for water management have resulted in the failure to take sufficient account of environmental end-use and in-stream requirements. Moreover, where water rights are not fully or consistently defined, irrigators have been able to exploit unregulated water.

The next step in the trading market will be the implementation of cross-border trading between states. Although some transactions have been arranged, the transfer of water has never been completed. Such a trading system may improve allocative efficiency of water use further. The Australian Bureau of Agricultural and Resource Economics "looked at eighteen regions in the southern Murray Darling Basin and found that at current water prices, the gains from interregional water trading would be approximately A$50 million" (Anderson and Hill, 1997: 141). Legislative barriers currently prevent individuals from interstate trading in water rights and further cooperation between state governments is required.

Source: Anderson and Hill, 1997

4.2 Markets in rights

4.2.1. Water markets

For efficient resource use, resources should reach those activities with the highest marginal social benefit. In most cases, the large numbers of users and their heterogeneous interests, the asymmetry of information available to the institution allocating rights, and pressures for equitable allocation, will produce an initial allocation of rights which is suboptimal. The subsequent transfer of rights allows low-value users to exchange permits with high-value users. Payment at market prices provides full compensation for the loss of the right.

A number of conditions must be met for a market to allocate permits efficiently. The prior agreement and definition of rights is the basis for trade. Second, rights must be valid for a sufficiently long time that owners can assign a value to them. Information about the nature and scope of rights and the rules of trading must be clear to allow both buyers and sellers to understand the full implications when assessing potential trades (Dinar et al., 1997a). If transaction costs are low, and the infrastructure required for the legal transfer of rights and the physical transfer of water exists, market for water rights can develop (Anderson and Hill, 1997).

When the transfer of a right involves a change in use of the ecosystem, the full implication of this trade should be reflected in the price; that is the full costs of resource use should be reflected in the price. Some markets do not allow the transfer of ecosystem resources, such as water, between uses. This may prevent some trades, which would have improved efficiency, from taking place. Table 5 presents the number of approved water rights transfers between 1975 and 1984 in the US. While many transfers do not change water use, a significant proportion allow a change of use, most commonly from agriculture to industry or households.

Rules and regulations over the transfer of water rights are necessary to ensure that market transfers produce net social benefits. Externalities are pervasive in water transfers. For economic efficiency to be reached, water rights holders must bear the full opportunity cost of their actions, i.e. external effects must be accounted for in transfer decisions. If this does not occur, external costs will be borne by society as a whole. This suggests that, to ensure water markets do yield net social benefits, water marketing must be conduced in an institutional framework which forces buyers and sellers to take account of third party impacts. This means that most transfers of water rights must be regulated. Unfortunately, a certain degree of complexity of regulations is unavoidable due to heterogeneity between users and uses. This produces high transaction costs. An important issue is therefore whether and how regulations can be simplified.

In Wisconsin, USA, pulp and paper mills and municipalities discharge waste into the lower reaches of the Lower Fox River. Tradable discharge permits were allocated to existing polluters in an attempt to improve water quality through least-cost reductions in discharge. Ex ante studies, or those based on forecasts rather than results, found a fourfold difference in abatement costs between firms. Despite the potential for

Table 5 Percentage of Approved Changes of Water Rights, 1975-1984

US State	Purpose			
	Agriculture to Agriculture	Agriculture to Non-agriculture	Non-agriculture to Non-agriculture	Non-agriculture to Agriculture
Arizona	42	22	33	3
California	35	26	37	2
Colorado	10	75	14	1
New Mexico	41	47	10	2
Utah	34	24	42 (From Non-agriculture to any)	
Wyoming	24	73	3	0

Source: MacDonnell, 1990

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trade in pollution permits arising from disparities in abatement costs, only one trade has taken place. The main cause is the complexity of the rules and regulations governing transfers that impose transaction costs on negotiators and create barriers to trade. Prior approval is required for each trade. The rules are complex in order to take account of different kinds of pollutants, emitted at different times and at different places on the river. Polluters are reluctant to propose transactions that they believe would be deemed be illegal.

Some reluctance to use market mechanisms to allocate freshwater ecosystem resources is due to the broader economic implications of such policies. In most countries, it is likely that trade in water rights would redistribute water resources away from agriculture to industry, and this would have serious consequences for rural areas. *Although it has been shown that at the state level, the secondary costs to the economy of water origin are not significant when compared to the benefits of improved efficiency, the distribution of costs may produce conflict.* The costs are borne by local economies while the benefits accrue to the locality importing the water. When water was transferred from agricultural to industrial use in the US, the negative effects were exacerbated by the use of sales proceeds to repay heavy farm debt and scarcity of local investment opportunities (Howe et al.,1990). Political opposition to economic restructuring produces conflict in the process of resource reallocation.

4.2.2 Water banks

The introduction of a mechanism that temporarily transfers the right to freshwater ecosystem resources is intended to minimise secondary effects throughout the economy. Water banking has been used in the US to efficiently and equitably transfer water between users for a limited period of time. The California Department of Water Resources established a drought water bank with the aim of transferring water from agriculture in northern California to urban, municipal and agricultural sectors in southern California. First established in 1976, the Water Bank initially facilitated sales and purchases only from public entities, which limited the potential for distribution improvements. By 1991, the rules of transfer had been altered to include private users. Large volumes of water were reallocated, in large part due to the fact that most of the water traded was from storage and could therefore be quickly and flexibly redistributed. This suggests that a great deal of hoarding existed prior to trading.

As water supply was greater than demand, the surplus was used for environmental projects and recharge. Rules in subsequent years were altered so that a guarantee of purchase was received before the bank undertook to buy water from a supplier, and demand was better matched with supply. Also, the supply of water from irrigated land that had been put to fallow was prohibited in order to erase criticism that the water bank had a negative secondary effect on agricultural employment (Anderson and Hill, 1997).

4.3 Pricing

4.3.1 Public water provision

A common method for controlling the consumption of freshwater ecosystem resources is to assign management to a central agency, most commonly a local or national government. The centralisation of allocation decisions is intended to internalise the full social cost of resource use. Again, we find the problem of management of large, complex systems. Assigning management responsibility to a single agency, does not guarantee that the agency matches the range of the system or that it has the instruments needed to manage the system effectively.

In 1918, it was decided to divert the two main tributaries of the Aral Sea, the Syr and Aru Darya. As a result, the lake shrank by 66 per cent. The land freed up by this shrinkage could not be used for agriculture due to salinity, and traditional economies based on fishing lost 60,000 jobs. It is estimated that 35 million people were affected, suffering health and economic problems due to salt storms and saline soil. The situation of the Aral Sea was a consequence of the Russian government's objective to increase cotton production for export. The needs of local populations were sacrificed for national economic concerns (Ellis, 1990).

It is difficult for centralised agencies to manage resources effectively in the context of a lack of knowledge about the local environment and organisations. The large number of interactions between users in freshwater ecosystems produces side-effects that range widely in nature and scope. Without detailed and specific knowledge of an ecosystem, a central agency is at a disadvantage.

Moreover, the conflicting aims of central government may prevent an optimal solution from being reached. Governments are elected for a limited period of time, and must win political favour. Perceived shifts in the equity of resource allocation have political, as well as economic implications. The size of policy changes considered acceptable to the majority decreases as the number and heterogeneity of parties being managed by the agency increases.

For example, to improve water quality, Latvia attempted to reform pricing policy to release capital for reinvestment in water supply. The primary concern of the water utility was that water should be affordable to households. The government felt it was inequitable to make the private installation of household meters compulsory due to high levels of unemployment. The Water Utility company was restricted to charging a maximum amount. The World Bank recommends that prices should not exceed 3 per cent of average household income. As a result, the maximum volumetric water charge was less than total average costs, and less than average operating costs (excluding the overhead costs and debt charges of the water utility). Despite a general commitment to achieve economic efficiency in water pricing, external factors prevented this (Merrett, 1997).

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Freshwater ecosystems provide resources critical for human and ecological survival. In some cultures, freshwater ecosystem goods are viewed as 'gifts of god' which should be provided free to all citizens. In many countries, state-run utilities and government-regulated franchises often subsidise the provision of freshwater ecosystem goods, charging prices below the true economic value of these resources. Consumers, therefore, do not attempt to improve the efficiency of use.

The demand functions for freshwater ecosystem resources vary according to use. It is common to differentiate tariffs for the agricultural, domestic and industrial sectors. The commercial demand for freshwater ecosystem goods has been found to be more elastic than residential demand, implying that a smaller change in price is necessary to affect commercial rather than domestic consumption (Espey et al., 1997). Governments, concerned with the reactions in their constituencies, base management decisions on a broad range of criteria unrelated to sound resource management. In short, the centralisation of management of freshwater ecosystems may be problematic when governments are concerned with unemployment, growth, getting re-elected, and so on.

4.3.2 Decentralisation – Privatisation, regulation and representation

The privatisation of public utilities, and effective regulation by government, is intended to reconcile the need for profit maximisation by the individual supply firms with equity concerns. Such systems have been developed in England and France, and suggest that some form of regulation and representation is almost always required to ensure that under-represented uses and users (including environmental goods and services) are provided for within a private system.

In 1974, regional water authorities were created in England and Wales to manage both water utilities and river basin functions (Merret, 1997). In 1989, the utilities functions of these authorities were transferred to independently regulated private firms, while environmental functions, such as flood defence and pollution control, remained under public control. "Environmental functions have to remain in the public sector, on clear principle, because they depend on regulation and enforcement (in legal terms), and because they involve the allocation of common natural resources and the provision of indivisible public goods (in economic terms)" (Kinnersley, 1993).

The benefits of privatising the water utilities were limited. First, operational efficiency gains within the regional water authorities were achieved before they were sold to encourage the initial privatisation (Kinnersley, 1993). Second, "the backlog of capital spending and the European Union's environmental legislation necessitated a large capital-spending programme, driving up overhead costs and pushing the rate of increase in charges well above the inflation rate" (Merrett, 1997). Rationalisation of the utilities involved large-scale job losses in a time of a high unemployment. Shareholders seemed to gain relative to consumers, and the proportionate increase in salaries to directors was much higher than to other workers. The problems that privatisation had aimed to solve were replaced rather than eliminated (Kinnersley, 1993; Merrett, 1997).

Another form of decentralised management is based on the participation of users in the supply and management of freshwater ecosystem goods at the local level. Water User Associations (WUA) have been established in many parts of Asia to promote management of water resources at the local level, where knowledge of the ecosystems used and organisational capacity is strongest. User Associations are particularly effective where the efficient allocation of freshwater ecosystem goods requires intra- rather than intersectoral reallocation (Dinar, 1997a). WUA are most successful when participants are small in number and/or homogenous in nature. Equity concerns tend to receive priority over efficiency criteria. Nevertheless, user associations rarely encompass all factions of society.

Privatisation of water resource management may efficiently provide a flow of services to users, but these users tend to be the more powerful user groups (urban households and industry). The scope for privatisation is limited because establishing private property rights is not an option for some services provided by ecosystems. Uses for environmental services – the support of other species and their habitats – are more appropriately provided by regulation.

A basic problem is the under-representation of many uses and user groups, and the failure to incorporate their opportunity costs within resource allocation decision-making. Institutions should focus on mechanisms that value, register and internalise these opportunity costs into their decision-making processes (Swanson and Vighi, 1998). This involves explicitly placing value on currently under-represented uses (habitat, wildlife, recreation) and bringing these into balance with those that have been historically over-represented (agriculture and industry).

4.4 Addressing the problems of managing ecosystems

This section has introduced a number of tools for managing freshwater resource systems: tradable permits, water pricing, privatisation and regulation. It is clear that the selection of policy instruments depends on the nature of the resource in question and on institutional capacities at national, regional and local levels. The complexities of natural systems do not allow simplistic solutions.

In short, what is required to effectively manage freshwater ecosystems is the continuing evolution of resource-focused management institutions. Institutional development should focus on the set of problems that are inherent in ecosystem management; that is to identify functional relationships, opportunity costs, and optimal charges. It is not possible to manage natural systems effectively when management is also trying to pursue social goals.

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5. Conclusions on freshwater ecosystem management

The fundamental conclusions of this paper are:

Foundational System

- The freshwater ecosystem provides a flow of services that lies at the base of most economic sectors and activities.
- In particular, the freshwater ecosystem provides a foundation for many public and collective goods (environmental goods, species habitats) that will not persist without a reserved allocation.
- The allocation of freshwater ecosystem services between many sectors, goods and activities will determine what continues to exist in future.

Complex System

- The freshwater ecosystem generates a flow of services that links a large number and variety of uses and users.
- The freshwater ecosystem is affected by these uses in many ways, and the nature of the relationship between an economic activity and its impact on the system is not always readily apparent.
- The freshwater ecosystem crosses many and varied management boundaries, generating institutional complexity and conflict.

The Freshwater Ecosystem Management Problem

- The management problem is to reallocate the flows of goods and services of freshwater ecosystems to their socially most valuable uses.
- The optimal solution requires: 1) an understanding of the functional relationships between activities and impacts; 2) estimation of the opportunity costs of resource use; and 3) the internalisation of this cost to each use and user.
- The accomplishment of these tasks in the simplest possible context (uniform uses and users) is costly and difficult – the accomplishment of this task in the context of systemic complexity (natural and institutional) is very difficult.

Towards a Solution in the Management of Complex Systems

- The first step toward addressing this problem is to separate two facets of the freshwater ecosystem – its foundational status and its complexity. The management of the resource cannot address all of the aspects arising out of its status as a foundational good. If this is not done, then all social problems (employment, growth, poverty, insurance) are being managed through this single resource. These other problems must be addressed via other instruments.
- The second step toward addressing this problem lies in finding the correct balance of uses of the system, given the range of users and uses, and their impact on each other.
- The third step toward addressing this problem is therefore to recognise that freshwater ecosystems have more in common with networks than with commodities. The fact that the system is an important asset in itself suggests that more complex forms of regulation are required than simply transforming the water that flows through the system into a commodity. Water systems must be seen as social assets, and management systems must manage the system rather than a single commodity it carries.
- The fourth step toward addressing this problem is to recognise that preventing the most easily avoidable misallocations of resources provides a realistic policy objective. For this reason, it may be best to first identify those uses that are under-represented and undervalued in current decision-making, and to channel resources to these uses.
- The fifth step toward addressing this problem is to encourage freshwater ecosystem management as an opportunity for developing broader forms of cooperation and management across systems, sectors and boundaries. It is natural systems such as these that make the evolution of social institutions possible, precisely because they make it necessary.

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Freshwater Ecosystem Management & Economic Security

Final Statement and Workshop Report

Chair:

Koh Kheng Lian

Technical Coordinator:

Lucy Emerton

Regional Coordinator:

Hans Friederich

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Final Statement

Vision for Water and Nature Workshop, Bangkok, Thailand, June 9-11, 1999

Vision

We would like to see a world where all freshwater ecosystems are managed and used for economic security in a fair and equitable manner, in ways which can meet anticipated future growth in human population and demand, and that do not compromise – and may even restore, where feasible – the ecological, biological and hydrological integrity of freshwater ecosystems.

Goals

By the year 2025:

- Positive and enabling economic measures for sustainable freshwater ecosystem management will have been set in place at global, regional, national, sector and local levels;
- Significant progress in overcoming the direct and underlying economic causes of freshwater ecosystem degradation and loss will have been made across all countries, in all sectors and for all socio-economic groups.

Preamble

There is general agreement throughout the water sector and among governments and civil society that the world is moving headlong toward a water crisis of profound proportions within the next 25 years. The increasing scarcity of water, brought about in many cases not by natural limitations but by ineffective management of water use, is already leading to political, economic and social conflict, in all sectors and at all levels of scale, and may ultimately undermine the security of all socio-economic groups and nations. What is less understood is that this building crisis is not limited to water itself, but will also affect freshwater ecosystems and the goods and services that they afford to humankind.

Although some international treaties and institutions have been created that indirectly address freshwater ecosystem issues, none of these deal fully or effectively with ecosystems and the intimate relationship of humankind to these ecosystems[1]. Additionally, as the workshop on Freshwater Ecosystem Management and Economic Security clearly identified, nations do not always have the appropriate level of awareness of their rights and obligations vis-à-vis these institutions.

The Vision statement and Goals highlighted above, as well as the Challenges, and the Strategies and Actions proposed below in response to these, are the product of an intensive three-day consultative workshop, involving water and non-water sector specialists in key disciplines from around the world. The workshop statement refers directly to solutions that are needed if the balance between freshwater ecosystem management and economic security is to be restored. Similar Vision statements are also being developed through separate consultations to address aspects of social and environmental security as they relate to freshwater ecosystem management. Together these three elements will form the foundation of a global Vision for Water and Nature, as an integral component of the Vision for Water, Life and the Environment for the 21st Century.

The workshop statement consists of the Vision itself, a realistic set of Goals that should lead us to that Vision by the year 2025, and a spectrum of Challenges that will have to be overcome in arriving at this desired outcome. The Challenges overlap in many cases. This is indicative of the complexity and interwoven nature of the links between economic security and freshwater ecosystem management, including a wide range of potentially conflicting environmental, socio-economic, cultural and geopolitical factors. A number of Strategies are specified to combat and overcome these Challenges, and form the pillars upon which recommendations for concrete Actions are based. These Actions also overlap, and in many cases the same Actions will have effect in relation to more than one Challenge and utilise more than one Strategy, at more than one level (local, national, regional or global).

Challenges

Under the status quo there exist certain conditions and circumstances which hinder and constrain the sustainable management of freshwater ecosystems. These challenges must be addressed if we are to meet the goals and attain the vision for the future stated above. The most immediate need is to address the challenge posed by rising water demand and imminent water crisis. In line with increasing population, urbanisation, industrialisation and commercialisation, and as both modes of production and settlement patterns undergo change, competition is intensifying and demand for water is rising rapidly. This has already caused ecosystem degradation, led to social and political conflict, and begun to undermine economic security at all levels of scale. There is a real risk, which may soon become a certainty, that local livelihoods, national economies and global production and consumption patterns will all be endangered by water scarcity. There is therefore an urgent and pressing need to respond to this imminent crisis by setting in place measures to cope with increased water demand, freshwater ecosystem stress and their resulting social, economic and political implications. A number of other serious challenges are connected to these trends, thus requiring immediate action, including:

1. The Ramsar convention is a notable exception, but here again it is focused on wetlands and not all aquatic ecosystems.

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Challenges posed by weak or perverse economic incentives

Under current conditions, conservation[2] is often not economically attractive or affordable – to the governments, industries, households and other socio-economic groups whose livelihoods and production and consumption activities depend or impact on the integrity of freshwater ecosystems. Simultaneously, a wide range of economic activities and forces (such as perverse subsidies, distorted prices and market failures) lead to freshwater ecosystem loss because they make it more economically desirable for people to degrade rather than to conserve freshwater ecosystems in the course of their production and consumption activities. The challenge will be to set in place positive and enabling economic incentives for sustainable freshwater ecosystem management at the same time as taking steps to identify and overcome the direct and underlying economic causes of their degradation and loss.

Challenges posed by economic inequity – acknowledging individual and communal rights and responsibilities

Different countries and users do not have equal power or equal access to water and other freshwater ecosystem goods and services. The poorest and most vulnerable groups, such as small-scale subsistence users and developing countries, are often ignored in decision-making processes which determine the management and use of freshwater ecosystems. This is particularly of concern where these groups rely most on freshwater ecosystem goods and services for their economic security, and therefore stand to lose most when freshwater ecosystems are degraded and lost.

The basic tenet of economic security is empowerment of communities and local resource users through just and fair rights, responsibilities and access to the freshwater ecosystem goods and services necessary to their survival. Secure rights, as well as participation in decision-making processes, both increase local economic security and enhance the sustainable management of freshwater ecosystems.

The economic requirements of different socio-economic groups and sectors, and their needs for freshwater ecosystem goods and services, are often incompatible and conflicting. The economic needs and requirements of different groups and sectors must all be represented and taken into account when decisions are made about the management and use of freshwater ecosystems. Freshwater ecosystems must be managed, and their goods and services allocated, in an equitable way which does not marginalise weaker groups or countries.

Challenges posed by inadequate financial resources, human capacity and information

The level of funding allocated to freshwater ecosystem management is low in relation to requirements, and there is often weak capacity to deal with technical, economic and managerial aspects of freshwater ecosystem management. A greater quantity, and quality, of funds, human resources and training are required for sustainable freshwater ecosystem management.

There is insufficient knowledge about the hydrology, ecology and biology of freshwater ecosystems, or their economic importance for different uses and users. It is necessary to understand these attributes and values, as well as the workings of freshwater ecosystems, in order to design management systems which meet the needs of diverse stakeholders while optimising both economic and conservation benefits.

Challenges posed by poorly planned development and conservation activities

While most environmental impact assessments do not properly quantify the economic effects of proposed changes or the recommended mitigation and prevention strategies designed to protect the integrity of freshwater ecosystems, economic planning tools – such as cost-benefit analysis – tend to ignore or at least seriously undervalue the economic worth of freshwater ecosystems. Rather than seeing economic development and freshwater ecosystem conservation as incompatible, it is necessary to balance and combine strategies for freshwater ecosystem protection, development and wise use in development and conservation planning.

Challenges posed by weak and inappropriate institutions, policies and legal frameworks

The institutions, policies and laws with which to govern freshwater ecosystems are often absent and, where they exist, are often weak, fragmented and sometimes contradictory. Good institutions, policies and laws are essential for sustainable freshwater ecosystem management. Supportive and enabling policies, and institutional and legal frameworks for freshwater ecosystem management should be put in place to recognise both economic and conservation goals – which represent the needs of all users, are politically acceptable, and can be practically implemented.

2. Note that the term 'conservation' as used in this document implies both protection and sustainable use.

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Challenges posed by public perceptions and attitudes towards freshwater ecosystems

Many freshwater goods and services, including water, are seen as free goods which can be converted, depleted, polluted or 'mined' (in the case of non-renewable aquifer waters) at no private cost. Users of freshwater ecosystems often feel no responsibility towards their good management and wise use, and lack the means or motivation to effect changes which will enable this. The resulting freshwater ecosystem degradation gives rise to high and sometimes irreversible social and economic costs, which may be inequitably borne among various user groups or among other stakeholders not responsible for this degradation. Present attitudes towards freshwater ecosystem utilisation and management must change to emphasise their vulnerability and the finite supply of their goods and services, and thus to modify unsustainable and damaging consumption patterns and production technologies.

Challenges posed by interdependencies between ecosystems and within river basins, and especially in transboundary freshwater ecosystems

There has traditionally been a tendency to ignore economic, ecological and hydrological linkages between upstream and downstream areas in freshwater ecosystems, and with the other ecosystems where economic activities impact upon (such as in forests, rangelands and farmlands), or themselves are impacted on (such as coastal and marine zones) by the integrity of freshwater ecosystems. This failure to understand and act in accordance with these ecological interdependencies threatens the integrity of freshwater ecosystems and undermines economic security.

Water is often dealt with in isolation from other freshwater ecosystem goods and services. This impacts on management by increasing the fragmentation of institutions, laws, policies and approaches which touch on freshwater ecosystems. There is a need to ensure that freshwater ecosystems are seen as holistic units, not just as a series of separate goods and services.

Freshwater ecosystems, especially river basins, frequently cross-cut national, ethnic and economic boundaries. Traditionally, there has been little cooperation, especially on a regional scale, in their management or in the design and implementation of laws, policies, institutions and management practices governing them or the impact on their integrity. Linkages between global, regional, national and local concerns are also weak. Ensuring that there is dialogue between different countries and levels of scale, and that policies, laws, institutions and practices are harmonised, is a major challenge in the sustainable management of freshwater ecosystems.

Strategies

Recognising these challenges, and attempting to meet these goals, a clear strategic process must underpin actions to achieve sustainable freshwater ecosystem management and economic security. The guiding principles for this process are to integrate freshwater ecosystem concerns into economic planning and development, and to integrate economic concerns into freshwater ecosystem management. Additionally, the process must recognise the fact that availability of fresh water for all human and natural ecosystem requirements is increasingly threatened. Thus, these strategic measures proposed for achieving the sustainable management of freshwater ecosystems for economic security include:

1. Ensuring that sustainable freshwater ecosystem management is economically desirable, equitable and viable for all stakeholders.
2. Improving knowledge and understanding about economic, ecological and hydrological aspects of freshwater ecosystems, and integrating lessons-learned from the field into national and global discussions, as well as translating national and global discussions and decisions into appropriate local-level actions.
3. Managing freshwater ecosystems in an integrated fashion: at a cross-sectoral, transboundary and basin-wide level, integrating local and national interests and attempting to combine both conservation and sustainable use goals and equitable benefit-sharing.
4. Considering and harmonising the needs of the different users of freshwater ecosystems and of the ecosystems themselves, recognising the impacts that these users cause, and the impacts that they in turn suffer, by impairing the integrity of the ecosystem.
5. Adopting measures that improve the efficiency of water use and reduce per capita consumption, especially at household, agricultural and industrial levels.
6. Challenging the belief and assumption that water is a free good that can be used and depleted at no economic cost.
7. Ensuring that all freshwater ecosystem concerns are reflected in appropriate policy, legal, institutional and economic frameworks, at local, national, regional and global levels.
8. Addressing conflicts in global policies affecting freshwater ecosystem management; in particular, discrepancies between the World Trade Organisation and multilateral environment agreements.

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Actions

The strategies outlined above should guide the choice of concrete actions for sustainable freshwater ecosystem management. An important consideration is that actions should aim to take account of the array of biological, ecological and hydrological attributes and requirements of different components of freshwater ecosystems, as well as the full range of economic needs, constraints and aspirations of different uses and users. We propose a number of mutually supporting actions, which relate specifically to – but also cross-cut – the challenges and strategies in sustainable freshwater ecosystems management identified above. These actions are grouped into four categories:

1. Improving knowledge, understanding and awareness

- Define the different components of freshwater ecosystems, including ecological, biological and hydrological aspects, and assess their interrelationships, especially upstream and downstream linkages.
- Assess how freshwater ecosystems relate to other ecosystems (especially linked upstream and downstream ecosystems) in ecological, hydrological and economic terms.
- Increase knowledge and understanding of how freshwater ecosystems relate to economic production and consumption, how different stakeholders depend on freshwater ecosystems, and how freshwater ecosystems contribute to economic security.
- For different cases and sites, define and determine threshold levels of environmental indicators that measure the health of freshwater ecosystems.
- Refine and modify economic analysis, development planning and economic indicator methodologies to include the value of the economic benefits associated with freshwater ecosystems, and the economic costs associated with their degradation and loss.
- Raise awareness on the importance of freshwater ecosystems to human societies and economies, and to development planning and implementation.
- Raise awareness at national levels of obligations relating to freshwater ecosystems under international agreements and conventions.
- Record, share and disseminate experiences and lessons-learned in freshwater ecosystems research and management.

2. Making sustainable freshwater ecosystem management economically attractive and sustainable to stakeholders

- Set in place positive incentives, and identify and overcome perverse incentives and disincentives, to the sustainable utilisation and management of freshwater ecosystems.
- Integrate freshwater ecosystem concerns into local, national, regional and international development planning and economic indicators.
- Source additional, innovative and sustainable forms of finance for freshwater ecosystem management.
- Ensure that the funds raised for freshwater ecosystem management are accrued by the groups who bear the direct and opportunity costs.
- Identify the economic benefits associated with freshwater ecosystem conservation and ensure that these are equitably distributed and, where appropriate, reflected in prices, policies, and economic decisions.
- Identify the direct and underlying economic causes of freshwater ecosystem degradation and ensure that the resulting costs are reflected in the decisions of producers and consumers.
- Develop and pilot appropriate, acceptable, flexible and mutually-supporting packages of economic instruments such as:
  - Promoting water use efficiency and ensuring that users consider the scarcity of water and other freshwater ecosystem goods and services, especially in urban, agricultural and industrial uses (e.g. through demand management, tariffs, improved markets and proper pricing);
  - Making the polluters and degraders of freshwater ecosystems responsible for covering the costs they incur (e.g. by the imposition of pollution charges, restoration bonds, fines and other penalties);
  - Increasing user participation and benefits in freshwater ecosystem management and conservation (e.g. through developing new markets, new management arrangements and partnerships between public, private and community sectors);
  - Ensuring that catchment areas and countries are socially and economically compensated for maintaining the source of freshwater ecosystems (e.g. through transfer payments, conservation-for-debt swaps);
  - Raising finance for water quality improvement and ecosystem conservation (e.g. through effluent fees, water charges, the development of new markets and pricing structures, international financial flows and private investment);
  - Promoting technologies that help to improve efficiency in the use of water and other freshwater ecosystem goods, and avoid or mitigate pollution and other negative ecosystem impacts (e.g. through differential taxes, preferential credit or waiving of duties);
  - Mitigating conflict between different water users (e.g. through differential taxes and subsidies on alternative and competing technologies and products, and through transfer payments, rewards and penalties).

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3. Balancing needs through integrated freshwater ecosystem management

- Integrate development and conservation aspects of freshwater ecosystem management through a cross-sectoral approach;
- Promote consultation and cooperation between the different users of, and stakeholders in, freshwater ecosystems, including upstream and downstream, cross-border and inter-sectoral stakeholders.
- Promote international cooperation in the management of transboundary freshwater ecosystems.
- Make efforts to resolve conflicts and discrepancies in the management of freshwater ecosystems, and the costs and benefits arising from them, between different levels of scale, sites, sectors and countries.
- Promote the equitable sharing of freshwater ecosystem goods and services, and of the benefits arising from their conservation and sustainable use.
- Promote equitable cost-sharing in the management and utilisation of freshwater ecosystems, and in the financing of their conservation.

4. Establishing policy, legal, institutional and economic frameworks

- Set in place institutions, policies and laws which govern freshwater ecosystem management and which support and include the use of economic measures.
- Harmonise and coordinate conflicting, fragmented and mutually-contradicting laws, policies and economic measures relating to freshwater ecosystems utilisation and management, between sectors and countries.
- Integrate freshwater ecosystem management into the aims and workings of regional trade blocks, economic communities, political alliances and river basin authorities, and make these agreements legally binding.
- Ensure the ratification, and implementation, of global, regional and subregional agreements relating to the sustainable management of freshwater ecosystems.
- Build technical, institutional and managerial capacity for the management of freshwater ecosystems and the use of economic tools.

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Workshop Report

1. Introduction

The purpose of this report is to provide a summary of the discussions and outputs of the Freshwater Ecosystem Management & Economic Security Workshop held in Bangkok, Thailand, June 9-11, 1999.

This workshop was the second of a series of three inter-linked workshops which will form the heart of the consultation process for the Vision for Water and Nature component of the World Water Vision (see Annexes 1 and 2 for description of both processes). The consultations, leading to the creation of a Vision for Water and Nature, are being undertaken by IUCN – The World Conservation Union at the request of the World Water Council.

The objective of this workshop was to develop a Vision statement for Freshwater Ecosystem Management and Economic Security, as a part of the Vision for Water and Nature.

The workshop brought together 24 professionals with a wide variety of geographical and technical backgrounds and expertise related to economic security issues associated with freshwater ecosystems and water resources management. A full participant list can be found in Annex 3.

As a starting point for debate, a draft discussion paper[3] was tabled. In addition to this discussion paper, inputs were sought from all participants prior to the workshop to round out the basis for discussion. All participants were invited to submit 300-word statements on the two or three crucial elements to be addressed by a Vision statement on water and economic security.

During the workshop, a combination of plenary and smaller working group sessions examining specific topics were used to arrive at the final workshop statement. Additionally, as this is only one part of the overall World Water Vision process, participation from and links to other sectors of the World Water Vision were worked into the proceedings.

At the conclusion, a Final Statement on Freshwater Ecosystem Management and Economic Security was produced and discussed. This main output of the workshop will feed into the development process for the Vision for Water and Nature as a whole.

3. *Swanson, T. and C. Doble. 1999.* Freshwater Systems, Conflict Management and Economic Security. *IUCN – The World Conservation Union, 72 pp. (Draft in Progress).*

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2. Workshop Discussion Report

The workshop aimed to facilitate discussion by adopting a format that combined working groups with plenary sessions, in order to maximise the contribution of participants' expertise and their diverse backgrounds. The agenda was developed to allow a free and critical discussion on the institutional processes affecting freshwater ecosystem management and economic security. The final agenda can be found in Annex 4.

The Workshop was opened by a welcome from Hans Friederich, representing the host organisation, the IUCN Regional Coordination Office for South and Southeast Asia (RCOSSEA).

The Chair for the workshop, Koh Kheng Lian, of the Faculty of Law at the National University of Singapore, provided a few words of introduction to clarify the purpose of the workshop in the context of the overall World Water Vision. She noted that threats to economic security from failure to adequately safeguard ecosystems differ from region to region. Because participants at the workshop come from many areas, she advised that it was therefore the task of all participants to try and apply their regional experiences to examine this complex topic from a truly global perspective.

However, she cautioned that in doing so we should be careful not to find ourselves 'reinventing the wheel.' A great deal of thought and progress on these issues was already contained in the product of the UN Conference on Environment and Development, Agenda 21, Chapter 18, and this document was distributed to workshop participants to refresh their memories and provide a starting point. Also, economic and financial sector information for the Asia/Pacific region was circulated to provide one regional perspective.

Finally, Koh Kheng Lian spent some time in exploring the questions "What is a Vision Statement?" and "What are the issues that must be considered in developing the Vision?" Not only must the Vision for Water and Nature pay due attention to the description of the future state of the world's freshwater ecosystems as we hope to see them 25 years from now, but it must also consider the economic tools, policies, and constraints that must be dealt with in order to achieve that desired vision.

Chris Morry, Project Manager for the Vision for Water and Nature, gave an overview of the Vision for Water and Nature process, stressing that this workshop is only one of three consultative workshops that are examining aspects of security associated with freshwater ecosystems management. Issues more germane to social security had been dealt with in a similar workshop in Harare, Zimbabwe, in April, while environmental security would be the topic of special attention in another workshop in San José, Costa Rica, late in June. Also, it was noted that Nature (or more correctly Environment and Ecosystems) is one of three principal sectors to be examined in developing the World Water Vision, along with several other topical issues, and in parallel with the development of regional visions representing the special concerns of specific geographic areas. Thus it was suggested that it is important to maintain a focus on the specific topic of each consultation, in the certainty that related topics and regional concerns will be dealt with in the appropriate fora. He concluded by encouraging participants to take part in other World Water Vision consultations, particularly those for their respective regions, to ensure that the issues and concerns of the environment are adequately addressed in those Vision consultations (see Annexes 1 and 2). In follow-up comments from the floor, concern was expressed that by sticking too closely to the topic of economic issues associated with freshwater ecosystem management, the risk existed that the workshop participants would not be able to find their place in the overall context of the World Water Vision. It was agreed that the working group sessions should be permitted latitude to range as broadly as they felt was necessary during their breakout sessions to avoid this potential myopia.

The Technical Coordinator leading the workshop was Lucy Emerton, of IUCN's Eastern Africa Regional Office (EARO). She outlined the proposed agenda for the participants, and received their concurrence to follow this course of work. The expected output was to be a Workshop Statement to feed into the Vision. Working groups were to start with establishing the issues, and then look at the factors that will lead toward economic solutions to deal with these issues.

To start the workshop discussions off on a suitable common footing, a Discussion Paper had been prepared by T. Swanson and C. Doble of the School of Economics, University College, London, that outlined the topic under examination. This paper was presented on behalf of the authors by Mr. Wolf Krug, also of the Department of Economics, University College, London. The paper looks at linkages between freshwater ecosystems and economic systems, and sets out to provide advice on how the two can best be harmonised to promote economic security. Without reviewing in detail the paper as presented, several noteworthy observations included:

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- Freshwater is required to meet both the human needs and natural demands of ecosystems. Social conflicts compound this by creating excessive and conflicting demands.
- Quality and quantity are factors in the utility of water for all uses, human and environmental.
- Externalities (uses not paid for and without reference to the needs of others) result in economic instability and inequitable distribution.
- Political boundaries do not reflect water's natural distribution patterns and this, too, leads to additional management dilemmas and conflicts.
- Of particular concern is the preservation of less-visible public good factors such as biodiversity.
- Misallocation and mismanagement are two sides of the same problem, related to economic activity and the impact on freshwater ecosystems.

The Discussion Paper, which had been distributed for review by participants in advance of the workshop, elicited a good deal of comment from the participants. Most felt that the paper was rather too theoretical to be a solid basis for the discussions that must take place. It needed more practical 'real world' examples of economic approaches to tackle the problems identified. Participants were encouraged to give such examples and to send others afterwards to help in the completion of the paper.

A few of the many useful examples suggested to illustrate various points included:

- mismanagement of land use in the upper Mississippi and Yangtze river basins leading to severe flooding incidents, as examples of environmental damage and economic hardship that can result from such mismanagement;
- a fledgling programme along the Yangtze River to compensate upstream residents for foregoing economic activities that could lead to harmful effects downstream;
- a similar water-pricing plan in California to compensate the upstream users for good water management;
- Singapore's dependence on Malaysia for water (water as an economic good);
- Uganda/Kenya's high dependence on hydro.

It was also noted that the paper focussed on demand management, not supply, and that it focussed too much on water as a resource, and not enough on freshwater ecosystems. Needs for economic development and conflict/equity issues were not addressed, or at least not fully explored. Nor were risk and uncertainty issues thoroughly addressed, especially risk associated with economic measures such as privatisation.

It was suggested and agreed that, while the Discussion Paper did have some interesting elements, there were some key gaps as mentioned above; therefore, discussion would draw elements from it, but not be based on it per se.

With this in mind, the Technical Coordinator, Lucy Emerton, suggested a framework of economic security by going over a number of basic economic principles underlying ecosystem' management that might help to focus the discussions:

1. Economic dependence on freshwater ecosystems, not just on the resource but also the services they provide;
2. Freshwater ecosystems as a source of economic security, i.e. a stable support for the economic dependencies, contribution to long-term economic growth, keeping future options open, etc.;
3. Economic factors linked to freshwater ecosystems degradation and loss;
4. Economic measures that promote wise use of freshwater ecosystems.

These, in turn, lead to two goals of economic processes related to freshwater ecosystems: the economic roles of freshwater ecosystems; and the consumption elements of development.

Before breaking into working groups for intensive examination of the issues and potential solutions to them in relation to economic security and freshwater ecosystem management, time was set aside for presentations on the outcome of the Social Security workshop held in Harare, April 13-15[4] by Gabriella Richardson (IUCN–HQ), and a quick optic on the Water for Food process by Thierry Facon (FAO) and the Water for People process by Wilas Techo (Population and Community Development Association, Thailand).

The two days of group discussions were designed as follows:

- Day 1 – Focus on context/issues
- Day 2 – Explore solutions

Together, these group discussions were intended to lead to the development of a final workshop statement, including a Vision statement as a contribution to the Vision for Water and Nature.

The manner in which this actually took place involved several stages. First, the participants were separated into two working groups to examine economic security in relation to freshwater ecosystem management from the differing perspectives of commercial and industrial users versus small-scale users – the so-called 'local livelihoods' perspective. The outcome of these two separate sets of discussions could then be challenged in plenary so that real distinctions were drawn out while apparent differences that did not hold up under cross-comparison were clearly identified. This step in the process helped to clarify the broad range of economic security issues that needed to be addressed in the workshop statement. It is also worthy of note that individual participants were encouraged to draw local and regional ideas from the 300-word briefs that they had been asked to submit prior to the workshop. This was particularly helpful in this phase of the Vision development process.

4. See Workshop Statement and Report *contained in this volume*.

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The next step was to divide again into two groups. This time, one group focussed on the most useful economic instruments that might be employed in addressing the consolidated list of issues now agreed to. The second group examined the questions of who should be responsible for effecting these economic measures and how this should be undertaken. Their discussions effectively isolated many of the Challenges that would have to be faced in achieving a Vision for economic security in relation to freshwater ecosystem management, and also proposed a number of Strategies to address these Challenges. When discussion resumed in plenary, the two parts began to merge into a series of concrete Actions that would form a part of the Vision statement.

Finally, a small writing team was set up to craft a first draft statement, which would include a simply-worded Vision to capture the essence of the discussions, a number of realistic Goals leading to this Vision, the identification of Challenges that would be encountered in achieving these Goals, and Strategies and Actions that would address these Challenges. This draft was then critiqued by all participants on the final day of the workshop, revised according to the consensus of views offered by participants, pending final editorial revisions following the workshop. The end result was the 'Final Statement' that forms the first part of this report. Further details on the individual group sessions are provided below.

2.1 Group 1. The uses and users of freshwater ecosystems: Commercial and industrial users

The aim of Group 1 was to set the context for and define the major issues to be addressed by the discussions of Day 2, specifically for commercial and industrial users of water. The main question put to this group was: How, why and by whom can economic measures be used for freshwater ecosystem management?

Before starting discussion on this specific topic, each member of the group presented his or her own expectations for the workshop. Common themes were to share information to help develop solutions, to integrate ecosystem concerns into economic issues (and vice versa), and, to identify processes to create synergies, instead of conflicts, between users of freshwater ecosystems.

The group then listed some of the main large scale-users (chemical industries, hydropower, municipal and agricultural use, etc.), and identified three key issues related to freshwater ecosystem management and economic security as being particularly relevant to these users:

1. Economic conflict

The main and ongoing conflict remains economic development versus ecosystem protection, or the trade-off between economic security and ecosystem integrity. Other conflicts could arise from competing economic uses (in particular, by upstream vs. downstream users); transboundary issues (whereby the relative power and topographical location of one country creates an imbalance in agreement on uses of a freshwater system); and poor institutional capacity.

2. Economic activity dominates ecosystem management

It was recognised by the group that economic activity historically tends to take precedence over ecosystem preservation. Multi-country policies tend to promote economic development over environmental protection. Traditional cost-benefit analyses do not usually allow for all (i.e. environmental) costs. It was, however, recognised that full-cost pricing and sale of water might disadvantage the poor.

Freshwater resources are usually used in two main ways: as a source of water and as a sink for pollutants and waste products. It was noted that commercial activity which affects a freshwater ecosystem (e.g. by using a river as a waste sink) often also depends on the same ecosystem to a certain degree (e.g. reliance on river to provide a certain quality of water). There exists a lack of effective demand and supply management, leading to wasteful water-use practices. Finally, the globalisation of finance presents a particular challenge, as it could lead to fewer global environmental controls (e.g. the World Bank withdrew from the Narmada dam project in India due in part to environmental reasons, but the project will go ahead with other sources of financing).

3. Ecosystem management considerations dominate economic activity

The group recognised that some cases exist whereby environmental considerations led to the cancellation of economically attractive development projects (e.g. Great Whale hydropower development project in Canada). It was agreed that social goals should not be ignored; however, a difference in priorities exists between the South (where development to achieve social goals such as poverty alleviation take precedence) and the North (which can 'afford' to stop development projects).

2.2 Group 2. The uses and users of freshwater ecosystems: Local livelihoods

The aim of Group 2 was similar to Group 1, except that their approach was to adopt a focus on the local livelihood level: to set the context for, and define the major issues to be addressed by, the discussions of Day 2, specifically for local communities. Once again, the main question put to this group was: How, why and by whom can economic measures be used for freshwater ecosystem management?

The definition of the task required identification, first of all, of the target user group – whom do we include in the term 'local livelihood level'? A somewhat simplified criterion that seemed appropriate was that this definition should include all those whose 'economic footprint' does not generally impact outside of the local area in which they reside. Following some debate, the following grouping was agreed to be inclusive of the varied user or stakeholder groups encompassed by this definition:

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Small-scale Users

- Small scale primary commercial – those involved in primary industries, such as agriculture, harvesting or gathering of natural resources (e.g. fishing, timber);
- Small scale secondary commercial – those who hand produce products from such raw materials as mentioned above (e.g. smal-scale granaries, bakeries, fish processor, lumber producers, etc.);
- Households;
- Marginalised groups – socially, culturally and economically disadvantaged;
- Community collectives.

All of the above can be found in both urban and rural settings, and the differences in economic issues related to freshwater ecosystem management that affect their livelihoods, depending on where they reside, can be quite dramatic – so consideration must be given to this factor as well. On the other hand, some factors are the same to both urban and rural users; for example, their reliance upon a clean and secure water supply for their livelihood and well-being.

It was also recognised that, at some stage in their lives, many if not all of the individuals described in this grouping could also be included in the grouping of 'commercial and industrial users,' since they might earn at least part of their livelihood working in a large-scale factory or other commercial enterprise. But these issues were being dealt with by Group 1, and it was therefore decided not to attempt to cover this aspect of economic security associated with local livelihoods.

Having defined the users, it was agreed that there were important hidden uses that did not necessarily appear in a categorical listing of this kind. These are the so-called 'indirect uses' (i.e. the services of freshwater ecosystems, such as restoration of water quality, groundwater recharge, increasing soil fertility, flood attenuation, etc.) and the 'non-use values' (e.g. cultural and aesthetic values).

The second part of the task was determined to be the need to more-specifically identify the underlying causes and kinds of freshwater ecosystem degradation either attributable to these user groups, or impacting upon their security, or both. It was immediately recognised that many of the underlying causes of degradation were interlinked, one acting upon the other and vice- versa, complicating definition of cause-and-effect relationships. Nevertheless some distinct categories of causes could be identified:

General Causes of Degradation

- Population increase;
- Economic pressure;
- Overharvesting;
- Conversion;
- Pollution/waste/effluent/agricultural runoff;
- Intensification of farming/forestry;
- Northern consumption patterns (i.e. wasteful use of resources in the North, leading to increased pressure to exploit resources in the South).

There are a number of broad issues that must be considered in order to properly evaluate the relative importance on small-scale economics and livelihoods of the various causes of degradation described above, and the potential that may or not may exist to mitigate these causes at the local livelihoods level across the various user groups. Then, too, there is a specific subset of issues that are strictly economic in nature, that also have bearing on the cause-and-effect relationship and hence offer other opportunities for action.

Broad Issues

- Rights/responsibilities/accountability to and for freshwater ecosystems use, which leads to...
- Equity issues – equal or fair access to water and other freshwater ecosystems resources;
- Policy (local/national/international, including adequacy of regulations and enforcement);
- Water security (both quantity and quality);
- Conflicts, between and within sectors, between local livelihoods and commercial users, etc.;
- Ecosystem conservation – is this an 'economic' imperative?;
- Polluted water, again considering rights and responsibilities (user or polluter pays?);
- Health, including many economic effects at all levels.

Economic Issues

- Markets (access, ownership rights, information);
- Technology (availability);
- Globalisation (international trade, subsidies, structural adjustment);
- Access to credit systems;
- Economic instruments (taxation, charges, payment fees, cost of water).

Having debated the subject of economic security and its relationship to freshwater ecosystems in the above manner, the group found itself confronted with what appears to be a circular argument:

Which comes first (or should come first in our deliberations):

- Economic security depends on functioning ecosystems? OR
- To have healthy ecosystems, we first need economic security?

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In reality, there does not appear to be a simple answer to this conundrum. The interdependencies are so strong that neither can precede the other, either in time or in priority.

The group finally examined a number of impacts that have direct bearing on the ability of freshwater ecosystems to continue to provide economic security at the local livelihoods level. These impacting activities were categorised as:

- External – those activities not undertaken within the community and whose impacts are therefore not self-inflicted, demanding assistance and cooperation from outside to rectify;
- Internal – those activities for which the community itself is generally responsible, and can and therefore should be able to take effective action on its own, with some external assistance.

The examples given are illustrative and not meant to be a comprehensive listing.

External Impacts

- Catchment logging
- Dams
- Large scale irrigation/commercial farming
- Salt water aquaculture
- Upstream contamination
- Heavy metals
- Wetlands conversion

Internal Issues/Impacts

- Non-sustainable use
- Lack of information about alternatives
- Lack of secure/defined access rights/control
- Fragmentation of knowledge – whole system
- Pollution (internally-generated)
- Lack of cash/credit for alternatives
- Social change
- Health implications

By categorising impacts in this way, it was not intended to suggest that the former grouping is beyond the control of the local community and should therefore be neglected in favour of attending to the latter grouping, but rather that different approaches, with differing actors and levels of cooperation, would be required to attack the two groups of impacts.

2.3 Group 3. Economic measures: Which? (Design and choice – incentive measures, pricing, financing mechanisms, fiscal measures, policies, etc.)

The aim of Group 3 was to identify strategies for action to be included in the Vision statement:

- What economic tools and measures can be used to act on these issues and overcome conflicts in freshwater ecosystems management?
- What other broad conditions need to be fulfilled to enable the use of economic measures for freshwater ecosystems management?

Attempting to ascertain which economic instruments are available to effect beneficial changes in the way freshwater ecosystems are managed cannot be done without some understanding of how these measures could be most effectively employed and by whom. Thus the tasks of Groups 3 and 4 were somewhat overlapping. Nevertheless, an attempt was made to have Group 3 work at a more general level, and to observe the output of Group 4 afterwards and ensure that the correct actors and operating mechanisms were connected in the final analysis.

Group 3 initially attempted to develop a list of known economic instruments and to indicate which of these could be most effectively employed at the local, national, regional and international levels, to address the issues raised by Groups 1 and 2. The product of this type of analysis began to take shape as Table 1 below:

Table 1 Economic instruments applicable to freshwater ecosystem management at the local, national, regional and international levels

Instruments	Local	National	Regional	International (Global)
Full cash pricing				
Subsidies/taxes				
Property and access rights[1]				
Control				
Tradable discharge rights				
Tradable water rights				
Conventions				
Trade policies				
Transfer payments (compensation)				
Fees (per unit)				
Refundable deposits and bonds				
Discount rate				
Legislation and enforcement				
Legislation and litigation				
Financial resources and water banks				
EIA and conditionality				

[1] *Property, land, water, other ecosystem goods and services*

Upon second consideration, however, it was decided that all these economic instruments and others that might be found useful can more simply be categorised into one of four groupings:

- *Market-based Instruments*: those generally employed by financial institutions, corporations and the private sector in conducting business;
- *Non-market-based Instruments*: those employed by government (at any level) in regulating industry, controlling societal consumption patterns, or raising revenues for its own programmes and activities;
- *Non-market and Non-governmental Instruments*: such initiatives and incentive measures as generally employed by nature trusts (e.g. protected areas) and other environmental NGOs;
- *Hybrid Instruments*: those that combine two or more of the above in a comprehensive strategy.

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It was felt that this form of sub-grouping would be more useful in identifying the actors that must be involved, and the levels at which these instruments can be most effectively employed. The instruments that fit into each of these subcategories include:

Market-based Instruments

- Pricing
- Water markets
- Tradable discharge rights
- Tradable water-use rights
- Water banks

Non-market-based (command and control)

- Subsidies and taxes
- Property and access rights
- Trade policies
- Penalties and fines
- Set-aside programmes
- Privatisation
- Decentralisation
- Legislation, monitoring and enforcement

Non-market and non-governmental:

- Cost-benefit analysis (valuation)
- Environmental impact assessment
- Conventions
- Endowment funds

(Note that several of the above are arguably better placed in the second category)

Hybrid Instruments

- Refundable deposits and bonds
- Compensation

To move from this systematised listing of potential tools to an effective strategy the group re-examined the list of broad issues or concerns developed by Group 2 (see above for details):

Broad Issues

- Water security (quantity and quality)
- Ecosystem Conservation
- Equity issues
- Rights, responsibilities, accountability
- Policy (local, national, international)
- Conflicts (numerous)
- Health

A listing of strategies to address these issues was developed through brainstorming. Note that this listing is non-linear – it does not address point for point the issues in the list above, but may relate in some cases to several of them. It is also not meant to be taken as sequential or in any particular order of priority:

- Compensate catchment countries for maintaining source of transboundary freshwater ecosystems;
- Adopt legislation to utilise effluent fees and water charges to finance water quality improvement plans and freshwater ecosystem conservation.
- Utilise proper pricing for urban, agricultural and industrial water use to promote demand management that encourages efficient use of water and to provide for the maintenance of environmental in-stream flow requirements;
- Consider costs and benefits of implementing economic instruments;
- Use valuation techniques to value the economic importance of currently undervalued uses (e.g. habitat, biodiversity);
- Ensure that land tenure and water rights are secure and fair to promote sustainable ecosystem management for future generations;
- Ensure that the suite of economic instruments applied to freshwater use are diverse, dynamic and flexible enough to deal with new and emerging issues in freshwater ecosystems management;
- Consider the macroeconomic climate in selecting economic and non-economic instruments;
- Make economic instruments related to water use consistent with other social and economic measures;
- Mitigate conflict between urban and rural water demands;
- Ensure that adequate and sustainable sources of financing are provided to freshwater ecosystems management;
- Provide information and improve awareness among users, the broad public and policy makers (on impact of different users and uses on the ecosystem);
- Promote technologies for more efficient water use in the household and the agricultural and industrial sector;
- Develop and test new and innovative mechanisms.

Due to time constraints, a number of topics were not fully explored in the working group session:

- Which instruments fit best in dealing with each issue identified?
- What are the differences in instituting these instruments at the local, national and international levels?
- What are possible drawbacks of implementing these instruments?

These were later picked up in plenary, in order to integrate this list of recommended strategies with the recommendations on who should be responsible and involved and through what mechanisms and institutions (see more on this below).

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2.4 Group 4. Economic measures: How and who? (Implementation and decision-making – institutional responsibilities, collaboration/conflicts between sectors and levels of scale, integration into private sector strategies and actions, etc.)

The aim of Group 4 was to identify strategies for action to be included in the Vision statement. The questions put to the group were: Who is responsible for implementing economic measures for freshwater ecosystem management? How can it be ensured that different groups, sectors and activities are reflected in, and participate in, a plan of action? How can freshwater ecosystem concerns be integrated into the strategies, plans and decision-making of different sectors and groups?

The group opened with a short discussion on what is a freshwater ecosystem (FWE), and whether they should be considered public or private goods. Interestingly, no firm definition/conclusion was reached for either.

Some of the key stakeholders in freshwater ecosystem management were identified, namely: government institutions (local, national, regional); non-governmental decision making bodies (i.e. village committees); private sector; industry; development banks; NGOs, local associations; and civil society.

The group then went on to develop a series of challenges and strategies, which are summarised by topic in Table 2:

Table 2 Summary of Challenges and Strategies Identified by Group 4

Challenges	Strategies
1. Policy	
• lack of wetland policy • lack of enforcement/implementation of policy • conflicting policies (e.g. agriculture often takes priority) • most water policies 'regulatory' (tell what not to do), not 'enabling' (encourage action) • lack of finance for Freswater Ecosystems (FWE) conservation/misallocation of available funding	• strengthen and develop national policies and programmes that address economic, social and ecosystem imbalance • establish regional agreements that are legally binding to guide sustainable utilisation of FWE (i.e. provide economic compensation for FWE degradation) • multilateral donor and national governments should ensure that the EIA guidelines of development projects include consideration of economic security which is dependent on FWE
2. Institutional	
• lack of institutions responsible for FWE management • poor representation (e.g. elements of FWE management fall within several ministries) • lack of international cooperation (transboundary issues)/overlapping jurisdiction	• promote government-stakeholder consultations/ partnerships to develop collaborative policies for FWE management and economic security • break the cycle of development and debt: stop reliance on funding from external sources to ensure decision-making at national and local levels • national governments should ensure proper cross-sectoral coordination among ministries: 1) all those that are responsible for FWEs; 2) those ministries WITH economic/finance ministries
3. Information	
• lack of information and understanding on scientific, social and legal aspects of FWE management • lack of information and data on economic value of FWEs	• increase research to strengthen knowledge on FWE management in terms of: economic valuation; scientific data; legal instruments
4. Links between economics and FWE management	
• Cost-benefit analysis not accurate: under-valuation of FWEs • lack of multidisciplinary approach • level of human/economic development affects how FWEs are managed	• ensure national accounting systems take into consideration real values of FWEs (i.e. green accounting) • build a dialogue between macro- and microeconomists • charge people for direct use of nature and natural resources (hunting, fishing, tourism, river water extraction, papyrus) • make investors responsible for restoration of sites they exploit

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3. Conclusions and Next Steps

The key output from the workshop was the Vision statement, appearing before the introduction to this detailed Workshop Report. The Final Statement is not meant to be considered as a stand-alone document. Rather, the Vision described therein forms one input into the development of an overall Vision for Water and Nature. It will be brought forward at subsequent workshops and combined with similar Visions to be produced on social and environmental security. This having been said, comments are invited on the Economic Security Vision statement to validate its conclusions and to ensure that it has encompassed all relevant issues.

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Annex 1

World Water Vision

Throughout 1999 until March 2000, the World Water Council is developing a **Vision for Water, Life and the Environment in the 21st Century (World Water Vision)** to address the pressing issue of scarcity of freshwater in localised areas, and chart a course toward more sustainable and equitable use of water resources.

It is intended as an intensive consultation exercise, bringing together stakeholders and professionals, both within and outside the water sector, which is meant to take us from where we are today to where we need to be to meet future water needs. This process of study, consultation and promotion aims to:

- *develop knowledge* on what is happening in the water sector, and on trends and developments outside the water sector that will have an impact on future water demand and supply;
- *raise awareness of water issues* among the general population and decision-makers in order to foster the political will and leadership necessary to achieve the Vision;
- *produce a consensus* on a Vision for the year 2025 that is shared by all stakeholders;
- *contribute to a framework for action* with steps to go from vision to action.

The consultations will take place through a number of means:

- *Thematic Panels*: experts consider possible future developments in biotechnology, energy technology, information technology and institutional changes, and their implications for the water sector.
- *Scenarios*: a framework that describes possible futures and their driving forces.
- *Sectors*: professionals discuss strategic water issues in key sectors: Water for Food, Water and Nature, Water for People (supply and sanitation), and others.
- *Regions*: regional stakeholders will discuss and develop a regional vision: a desirable future and how to get there.

In addition, a website has been developed to facilitate broad-based consultations from all interested parties: http://www.watervision.org

Annex 2

Vision for Water and Nature

IUCN-The World Conservation Union has been asked to lead the development of a specific sector vision on **Ecosystems and the Environment (Water and Nature)**. This Vision for Water and Nature will be combined with and contribute to visions of the other sectors, as well as the regional visions addressing the geographically varying issues confronting different parts of the world.

To develop the Vision for Water and Nature, IUCN will call upon the advice of many specialists and interested organisations, not only in the water sector, but in different socio-economic and scientific disciplines that bear upon the use of water.

The key basis for consultations will be three workshops, focussing on the related themes of how management of freshwater and aquatic ecosystems affects **social**, **economic** and **environmental** security. At each workshop, participants will examine, as a starting point for debate, expert opinions captured in discussion papers which are intended to challenge conventional thinking. At the same time, all interested individuals will be invited to examine and offer their comments on these documents via Internet-based discussions. The three scheduled workshops are:

- Freshwater Ecosystem Management & Social Security, April 13-15, 1999, Harare, Zimbabwe
- Freshwater Ecosystem Management & Economic Security, June 9-11, Bangkok, Thailand
- Freshwater Ecosystem Management & Environmental Security, June 22-24, 1999, San José, Costa Rica

The draft Vision for Water and Nature will be submitted at the Stockholm Water Symposium in August 1999 and provision will be made, if required, for a final round of consultations to complete the Sector Vision. It will then be incorporated into the final product of the overall process: an integrated World Water Vision for the 21st century, to be tabled at the 2nd World Water Forum and associated ministerial conference in The Hague in March 2000.

A website has been launched to provide information specifically on the Water and Nature process, post key documents such as the discussion papers and workshop reports for downloading, and provide a forum for input into the consultations (http://www.waterandnature.org)

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Annex 3

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Annex 4

Freshwater Ecosystem Management & Economic Security Workshop Agenda

Bangkok, Thailand, June 9-11, 1999

Day 1	**Wednesday, 9 June, 1999**
8:00-8:30	*Registration*
8:30-9:30	**Opening session** Welcome – Hans Friederich, IUCN-South & Southeast Asia Region Opening remarks – Chair Overview on Vision for Water and Nature – Chris Morry Presentation of participants and expected outputs of the meeting – Lucy Emerton
9:30-10:00	**Presentation of the Background Document** The discussion paper for the Economics Stream – Wolf Krug
10:00-10:30	*Coffee Break*
10:30-11:30	**Discussion of the Background Document** Reactions from the floor
11:30-12:15	**Background on the Vision work** The Social Security stream – Gabriella Richardson The World Water Vision Water for Food component – Thierry Facon The World Water Vision Water for People component – Wilas Techo
12:15-13:15	*Lunch*
13:15-13:30	**Framework for discussion groups** – Chair
13:30-16:30	**Discussion Groups – Framing the issue** • Group 1. The uses and users of freshwater ecosystems: Commercial and industrial users • Group 2. The uses and users of freshwater ecosystems: Local livelihoods *(Coffee available during discussions)*
16:30-18:00	**Reporting work – Discussion groups**

Day 2	**Thursday, 10 June, 1999**
8:30-9:45	**Framing the issue** Report of discussion groups from 9 June Reactions from the floor
9:45-10:15	*Coffee Break*
10:15-12:30	**Discussion Groups – Exploring solutions** Framework for discussion groups – Chair • Group 3. Economic measures: Which? (Design and choice – incentive measures, pricing, financing mechanisms, fiscal measures, policies, etc.) • Group 4. Economic measures: How and who? (Implementation and decision-making, institutional responsibilities, collaboration/conflicts between sectors and levels of scale, integration into private sector strategies and actions, etc.)
12:30-13:30	*Lunch*
13:30-15:00	**Discussion Groups – Exploring solutions** (continued) • Group 3. Economic measures: Which? (Design and choice – incentive measures, pricing, financing mechanisms, fiscal measures, policies, etc.) • Group 4. Economic measures: How and who? (Implementation and decision-making, institutional responsibilities, collaboration/conflicts between sectors and levels of scale, integration into private sector strategies and actions, etc.)
15:00-15:30	*Coffee Break*
15:30-16:00	**Day 2 Closing Plenary** Outline of Draft Framework for the Final Statement Overview of Day 3 – Drafting team
16:00-18:00	**Reporting work** Discussion groups Vision drafting team produces a draft statement

Day 3	**Friday, 11 June, 1999**
8:30-9:30	**Proposing solutions** Report of Day 2 group discussions Reactions from the floor
9:30-10:00	**Presentation of the draft statement**
10:00-10:30	*Coffee Break*
10:30-12:00	**Discussion of the draft statement**
12:00-13:00	*Lunch (redrafting of the statement based on discussion)*
13:00-14:00	**Open presentations from participants**
14:00-15:30	**Finalising the redrafted statement**
15:30-15:45	**Closing Plenary** *(with coffee)*

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Freshwater Ecosystem Management & Environmental Security

Discussion Paper

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Preface

This paper is written as a contribution to the World Water Council's Vision for Water, Life and the Environment in the 21st Century (the World Water Vision). It is one of three papers, commissioned by IUCN, linking freshwater ecosystem management and human security. The other two papers investigate the links between freshwater ecosystem management and social security, and economic security (Soussan et al., 1999; Swanson and Doble, 1999). The primary objective of this paper is to summarise current thinking on the associations between freshwater ecosystem management and environmental security. The purpose of the paper is to stimulate and provoke discussion at a workshop to be held in San José, Costa Rica, in June 1999.

There are numerous different ideas incorporated in the concepts of ecosystem management and environmental security, and this paper is far from comprehensive. However, it is not intended to be a definitive statement, but rather aims to highlight the principal areas of concern in this field and to emphasize the challenges that face communities around the world as the twenty-first century approaches.

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Executive Summary

This paper has been produced to provoke discussion at a workshop to be held in San José, Costa Rica, as part of the World Water Council's Vision for Water, Life and the Environment (Serageldin, 1999). It is not intended as a definitive statement but aims to highlight the links between the management of fresh water and environmental security. It is hoped that it will provide the basis for dialogue about what is believed by many to be one of the most pressing issues currently facing humanity.

As the 21st century approaches, humankind is struggling with many complex problems related to management of fresh water ecosystems. Past mismanagement of these ecosystems has resulted in widespread environmental degradation, destruction of ecosystem functions and loss of wildlife habitat. There is evidence that human-induced changes in fresh water ecosystems have brought about reductions in environmental security.

For the purpose of this paper, environmental security is defined as:

that aspect of human well-being determined by the state of ecosystem resources and functions. The level of environmental security affects the extent to which the social aspirations, economic goals and ethical commitments of both present and future generations can be met.

The definition acknowledges the fundamental linkages between environmental security and management, economic development and the social well-being of people. This paper provides a review of technical issues related to freshwater ecosystem management and environmental security. Management strategies are considered within the context of a pressure-state-response model.

A number of issues associated with environmental security are presented and indices are used to show worldwide trends. However, it is recognised that statistics alone cannot adequately describe environmental security, and that there are limitations with all the indicators used. Not least, the complex nature of interactions between humans and the environment means that it is currently impossible to derive quantitative links between indices of pressure, ecosystem state and environmental security. Nevertheless, the indices provide a crude way of assessing temporal and spatial variation in pressures on freshwater ecosystems and environmental security. The data demonstrate that worldwide there is:

- increasing human-induced pressure on natural freshwater ecosystems;
- increasing degradation of freshwater ecosystems, in the sense that they are increasingly unable to provide the services which benefit humankind;
- greatest environmental security in countries which have most altered their freshwater ecosystems (i.e. developed countries).

Advocates propose ecosystem management as the modern and preferred way of managing natural systems. It is a management approach that aims to increase security through protection of the environment, maintenance of ecosystem functions, preservation of biodiversity and by ensuring sustainable development. There are numerous definitions of ecosystem management, but for the purposes of this paper it is defined as:

deliberate and conscious manipulation of ecosystem structure and/or function, or regulation of human uses of ecological systems, so as to retain defined and desired features and processes, and to meet human needs in an optimal and sustainable way.

Although largely accepted at the highest political levels, strategies for the practical implementation of ecosystem management are currently ill-defined.

Catchments provide the most appropriate physical entity on which to base freshwater ecosystem management. In this paper it is suggested that integrated catchment management (ICM) is the most practical strategy for implementing this. ICM is defined as:

the coordinated planning and management of the water resources of a river basin, considering its interaction with land and other environmental resources for their equitable, efficient and sustainable use at a range of scales, from local to catchment level (DFID, 1997).

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Good management practices introduce feedback mechanisms that both mitigate and adapt to the impact of human interventions in freshwater ecosystems. A range of technical measures that hold promise for ICM include:

- demand management;
- water recycling;
- desalination;
- water harvesting;
- wastewater treatment;
- watershed and groundwater resource protection;
- habitat protection;
- changes in the operation of dams and, in some instances, their decommissioning;
- rehabilitation and restoration of freshwater ecosystems;
- biotechnology.

However, there remain considerable impediments to the practical application of ICM principles. These include lack of:

- understanding of linkages between land-use patterns, hydrological regime and biotic response;
- data to support demand-management programmes;
- effective monitoring;
- practical methods to integrate environmental, social and economic aspects of freshwater ecosystems;
- methods for incorporating science within the decision-making processes;
- involvement of all stakeholders in decision-making;
- community organisation and environmental education;
- unambiguous laws/conventions governing the use of international watercourses.

Environmental security priorities in the developed and developing world are very different. In developing countries, the emphasis must be on 'elementary environmental care,' mostly oriented to meeting basic water supply, housing and waste disposal needs. However, this must be done in the context of overall management strategies that safeguard the environment and protect the natural resources on which so many people, particularly the rural poor, depend. In the developed world, the emphasis must be on protecting the few remaining natural and semi-natural freshwater ecosystems, ameliorating the impact of existing development and restoring degraded ecosystems. Although the priorities are different, it is a key tenet of this paper that the basic doctrine proposed within the ICM concept applies to both developing and developed countries.

Increasing environmental security through ICM requires that:

- issues of environmental change and security are dealt with holistically;
- ICM strategies satisfy both immediate and long-term needs;
- research findings are used to provide an analytical perspective of problems, guide policy-making and inform assessments of management interventions;
- resources are directed towards identifying vulnerable geographic regions and sectors of society and promoting adaptation and resilience in both;
- the impediments listed above are overcome.

This paper summarises three different future scenarios, developed, in draft form, by the Scenario Development Panel of the World Water Council. These provide very different visions of possible futures. In the 'conventional water world' it is postulated that if economic growth, technological advances and demographic trends continue as at present, by 2025 the problems impacting on freshwater ecosystems will be the same as today, but increased in number and consequences. At the global scale, there will be a net reduction in environmental security, particularly in developing countries. Alternatively, in the 'water crisis' scenario, it is postulated that if there is a slow-down in economic growth, less dissemination of new technologies and a failure to adopt water strategies, then there will be increased water scarcity and catastrophic reduction in environmental security in many regions. If the third scenario, a 'sustainable water world,' is to be achieved, with an associated increase in environmental security, then significant changes must be made in the way that humankind manages and utilises freshwater ecosystems.

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Acronyms

CBD	Convention on Biological Diversity
DSS	Decision Support Systems
EA	Environmental Assessment
EPA	Environmental Protection Agency (US)
FAO	Food and Agriculture Organisation (UN)
FERC	Federal Energy Regulatory Commission (USA)
GIS	Geographical Information Systems
HCC	Harare City Council (Zimbabwe)
ICM	Integrated Catchment Management
ICOLD	International Commission on Large Dams
IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated Water Resources Management
IWRSM	Integrated Water Resource Simulation Models
MDB	Murray Darling Basin (Australia)
MT	metric tons
MW	megawatt
UN	United Nations
UNCED	United Nations Conference on Environment and Development
USCOLD	US Commission on Large Dams
WCD	World Commission on Dams
WCED	World Commission on Environment and Development
WHO	World Health Organisation
WMO	World Meteorological Organisation

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1. Introduction

Giver and taker of life; essential element of all existence and untameable destroyer; spiritual expression of purity and contaminated purveyor of affliction; bringer of blessings and of tragedy; agent of social, economic and political discord. Water is all these things... (Page, 1997).

As with all species, humankind is dependent on functioning ecosystems to survive; ecological processes keep the planet fit for life. All organisms affect ecosystems, but only humans have the ability to significantly modify the environment to meet their own needs. It seems likely that as we approach the end of the twentieth century, humankind has altered, to a greater or lesser extent, nearly all natural systems on the planet. However, uniquely among the species on Earth, our cognitive abilities enable us to make choices about how we utilise ecosystems and the extent to which we alter them. In this regard, key questions that need to be asked are:

- To what purpose do we modify natural systems?
- How should we plan the limits to which we modify natural systems?
- At what point do human-induced changes in a natural ecosystem become deleterious?

The history of land-use in the developed world indicates that, in the most prosperous countries, the ecosystems that people most depend on are those whose function, composition and structure are far removed from natural systems. In most developing countries, many people remain directly dependent on ecosystems that are in a much more natural state. In recent years, concern about the modification of natural systems has been expressed for three reasons. First, it is not known if heavily-modified systems are sustainable in the long term. Second, the realisation that 'natural' (i.e. less modified) ecosystems provide both economic and social benefits to society, and that these benefits may be lost if an ecosystem is changed, has gained prominence. Third, it is felt by many that humankind has an ethical duty to 'protect nature' from the impact of human activities.

In the light of these concerns, the 'ecosystem management' approach has been cast as a new paradigm that reforms the way that humans interact with nature. In broad terms, ecosystem management seeks to 'restore and sustain the health, productivity, and biological diversity of ecosystems and the overall quality of life through a natural resource management approach that is fully integrated with social and economic goals' (White House Interagency Ecosystem Management Task Force, 1995). Although there are numerous definitions of ecosystem management, for the purpose of this paper it is defined as:

deliberate and conscious manipulation of ecosystem structure and/or function, or regulation of human uses of ecological systems, so as to retain defined and desired features and processes, and to meet human needs in an optimal and sustainable way.

However, what this means in terms of practical application remains far from clear.

Water, vital for life, plays a complex and multifaceted role in both human activities and natural systems. Its availability varies both spatially and temporally, and both too little (i.e. droughts) and too much (i.e. floods) have negative effects on human well-being. In an attempt to control water resources, humanity has manipulated freshwater ecosystems for thousands of years. For example, both the Sumerian and Egyptian civilisations flourished, in part, because of food surpluses derived as a consequence of elementary water management strategies (Newson, 1992). Traditionally, water management has focused on the direct provision of enough water for people to drink, grow their food and support industries. In the past, there has been very little consideration of environmental issues.

Today, the world is struggling with complex problems related to freshwater management. Many areas of the world face water stress, millions of people die annually from water-related diseases, human-induced change of freshwater ecosystems continues apace, and worldwide there are growing disputes over water. High population growth, increasing expectations and environmental degradation are increasing the severe strains on existing water resources. It is estimated that humans already appropriate more than half of all accessible surface water runoff, and that this may increase to 70 per cent by 2025 (Postel et al., 1996). The use of water by humankind impinges on the volume, quality and seasonal rhythm of fresh water, so that the effective share available for the rest of nature declines.

Management of fresh water is required to balance conflicting demands. The primary goal of freshwater ecosystem management is to maximise the long-term economic and social benefits to be gained from fresh water, while at the same time conserving ecosystem processes and biodiversity. Mismanagement of freshwater ecosystems may result in environmental degradation, destruction of ecosystem functions and loss of wildlife habitat, with a consequent loss in the benefits to humankind. There are instances where human interventions in freshwater ecosystems have induced, or at least contributed to, social disorder and violent conflict.

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The publication of the *Brundtland Report*: *Our Common Future* (WCED, 1987) and *Caring for the Earth* (IUCN et al., 1991), and the United Nations Conference on Environment and Development (UNCED) in 1992, mark a turning point in modern thinking and led to two interrelated concepts. The first is sustainable development, which has been defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." The second concept is that the lives of people and the environment are profoundly interlinked. This has lead to an alternative definition of sustainable development, i.e. "improving the quality of human life while living within the carrying capacity of supporting ecosystems." Based upon principles developed at water conferences in Mar del Plata (UN, 1977) and in Dublin (WMO, 1992), Chapter 18 of Agenda 21 develops the concept of Integrated Water Resources Management (IWRM). This treats "water as an integral part of the ecosystem, a natural resource and a social and economic good, whose quantity and quality determine the nature of its utilisation" (UN, 1992). Central to an IWRM approach is the protection of surface water and groundwater resources, water quality and aquatic ecosystems, and the management of land and water in an integrated way.

The Convention on Biological Diversity (CBD), to date ratified by 128 countries, recognises the links between biodiversity conservation and sustainable development. It acknowledges that biological diversity is more than just the sum of species numbers: it encompasses the variety, variability and uniqueness of genes and species, and of the ecosystems in which they occur. The Convention's overall objectives include the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising from its utilisation.

Hence, at the highest political levels, there is an increasing consensus on the need to manage water and water-related processes and ecosystems in a sustainable manner. However, at the local level, water is still often taken for granted and, in development, it remains the case that the value of ecosystems is rarely considered. A key problem for regional and local managers is how to allocate water between conflicting human demands and the requirements of the environment. It is often the case that the integrated effects of local management decisions are incompatible with the broader-scale wishes of society and the agenda of high politics. There remain serious challenges to confront before there is widespread and credible application of the ecosystem management concept. As we approach the 21st century, there are increasing constraints on human activities posed by the condition of freshwater ecosystems. The problems continue to escalate, and there is a growing feeling of an incipient world water crisis (Falkenmark and Lundqvist, 1998).

The increasing human pressures placed on freshwater ecosystems are a consequence of socio-economic states that ultimately arise from a number of global drivers, of which population growth, urbanisation and economic globalisation are the most significant. Although these aspects are touched on briefly in this paper, they are not discussed in detail; this is the task of the other two papers in the series (Swanson and Doble, 1999; Soussan et al., 1999). This paper focuses on technical issues related to reconciling freshwater ecosystem maintenance and water resource management.

The primary objective of this paper is to present a summary of current thinking on the link between the management of freshwater ecosystems and environmental security. Environmental security can, in simple terms, be considered as a state of human well-being arising from a stable, protective and unthreatening physical environment. Discussed in detail in section 2, for the purpose of this paper it is defined as follows:

> *Environmental security is that aspect of human well-being determined by the state of ecosystem resources and functions. The level of environmental security affects the extent to which the social aspirations, economic goals and ethical commitments of both present and future generations can be met.*

Section 2 provides an overview of the key concepts related to freshwater ecosystems, summarises the benefits these systems provide for humankind, and outlines the principle of environmental security. Section 3 is a review of the human-induced pressures currently acting on freshwater ecosystems, the current state of these systems, and the consequent implications for environmental security. As far as possible, numerical indices are used to summarise information about the complex interrelationship between people and freshwater ecosystems. In section 4, three scenarios – 'conventional water world,' 'water crisis' and 'sustainable water world,' are presented. These provide very different visions of possible futures. The implications for the state of freshwater ecosystems and consequent environmental security are considered in each case. Against this background, the concept of ecosystem management as a possible future strategy for resource management is presented in section 5. Various technical options for both mitigating and adapting to changes in freshwater ecosystems are discussed. A final statement, which draws together the key findings of this paper, is presented in section 6. In addition, a number of key issues are offered, to provide the basis for discussion at the Costa Rica workshop.

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2. Background

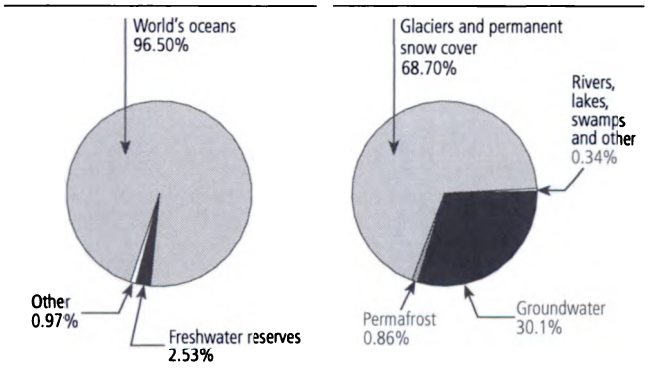
However much we learn to manipulate our environment, we cannot escape our dependency on biodiversity for food, medicines and materials or for the ecological services provided by healthy, diverse ecosystems
(Stephen Blackmore, Keeper of Botany, The Natural History Museum, London, 1996).

In this section, ecosystem concepts are discussed, and the services provided by freshwater ecosystems to the benefit of human societies are summarised. A definition of environmental security is sought, and the need for ecosystem management is addressed.

2.1 The global water cycle

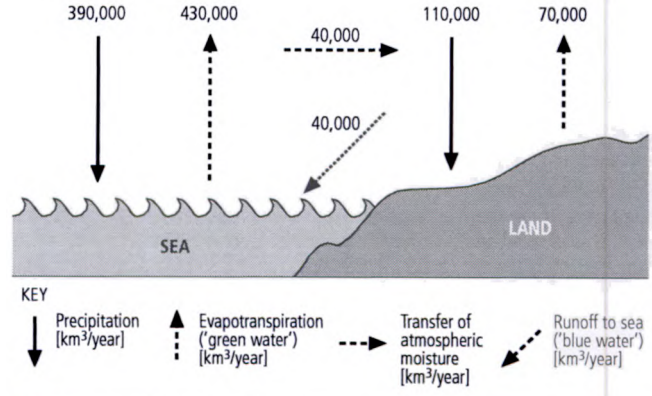
Fresh water constitutes only about 2.5 per cent of the total volume of water on Earth (see Figure 1). Two-thirds of this fresh water is locked in glaciers and ice caps. Just 0.77 per cent of all water (about 10,665,000 km³) is held in aquifers, soil pores, wetlands, rivers, plants and the atmosphere, and so circulates reasonably fast (Postel et al., 1996). It is the renewable, fast circulating fresh water which is of vital importance to humankind and to all other terrestrial flora and fauna. Precipitation over land is the overall fresh water available and is partitioned into 'green water' (evaporating vertically) and 'blue water' (flowing more or less horizontally) (see Box 1).

Figure 1 Global total water and freshwater reserves



Box 1 Hydrological Cycle

The hydrological cycle



Source: Postel et al., 1996

Only freshwater flowing in the hydrological cycle is renewable. The terrestrial renewable freshwater supply ($RFWS_{land}$) equals precipitation on land (P_{land}), which then subdivides into two major segments: evapotranspiration (ET_{land}) (i.e. 'green water') and runoff to the sea (R) (i.e. 'blue water'). Groundwater and surface water are often hydraulically connected and so soil infiltration and ground-water replenishment are included as part of this runoff component. Thus $RFWS_{land} = P_{land} = ET_{land} + R$.

A simplified depiction of the global hydrological cycle, adapted from Gleick, 1993

Global water budgets are derived from interpolation of climatic, vegetation and soil information for different geographical zones. The methods are inherently imprecise; estimates of annual runoff range from 33,500 km³ to 47,000 km³. The value of 40,700 km³, derived by L'Vovich et al. (1990) lies near the middle of this range.

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2.2 Concepts used in freshwater ecosystems

It is important to note that the ecosystem concept was initially developed as a research paradigm. It was never intended to serve as the basis for resource management (Fitzsimmons, 1996). Ecosystems are not real entities on the landscape, but rather an arbitrary division of the landscape into elements to accommodate some human perception of interaction (e.g. between species or the flow of chemicals through space). Hence, ecosystems are real only in the sense that they refer to biota or processes identifiable on the ground. Ecosystems "may be identified at multiple spatial scales by association of ecological factors, such as climate, geology, landform, soil, water, plants and animals" (Jensen et al., 1996).

In this paper, freshwater ecosystems are defined as linked landscape elements that affect the passage of 'blue water' from the land to the sea and 'green water' from the land to the atmosphere. As such, nearly the whole of the terrestrial milieu can be considered as part of freshwater ecosystems. Freshwater ecosystems encompass all the environmental units associated with river catchments, not only the whole length of the river channel, but also lakes, ponds, meadows, floodplains, fens and swamps, as well as the upland areas which drain into these. It can be difficult to define the boundaries of ecosystems and in the context of fresh water, it is in many instances the river catchment that is the most easily identified management unit (section 5.1.2). A river catchment is defined as the unit of land from which water flows downhill to a specified point on a watercourse. It is determined by topographical features that include a surrounding boundary or perimeter known as a drainage divide or catchment boundary. However, it is important to note that the use of river catchments as a management unit has limitations. These include the fact that groundwater catchments are often very different to river catchments because the movement of groundwater is often determined by geological characteristics, rather than topography. Furthermore, river catchments do not include the coastal marine habitats, the ecology of which are often dependent on the inflow of fresh water (see Box 2).

Box 2

The dependence of coastal marine ecosystems on freshwater ecosystems

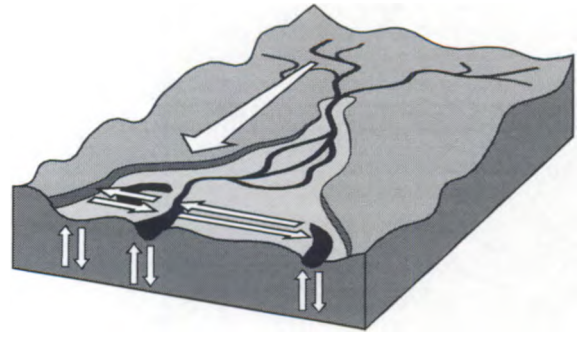
Material and energy fluxes ensure that all ecosystems are linked in both space and time. Coastal ecosystems highlight the fact that all ecosystems are interdependent. Changes in terrestrial freshwater ecosystems can have a considerable impact on the state of marine and estuarine systems. For example, the Indus Delta, an area of some 600,000 ha on the borders of India and Pakistan, is dependent on the outflow of fresh water and silt from the Indus River. In recent years the character of the delta has changed as it has been progressively deprived of 80 per cent of its average annual freshwater and silt inflow as a consequence of upstream abstraction for irrigation, occurring hundreds of kilometres upstream (Pirot and Meynell, 1998).

The construction of dams alters the flow regime of rivers, which in turn modifies the input of freshwater, nutrients and silt into marine systems. This often results in increased salinity and reduced productivity in estuarine and adjacent marine areas, with a consequent effect on associated fisheries. For example, in the Indus Delta, the creeks and mangroves provide excellent nursery areas for young fish, especially shrimp. Shrimp are a major export commodity, making up 68 per cent of the US$ 100 million which Pakistan earns from fishery exports. However, it is feared that shrimp and other commercial species will decline as the mangroves are lost as a consequence of human-induced changes, both locally and upstream (Meynell and Qureshi, 1993).

Reduced sedimentation, as a consequence of silt being trapped behind dams, can result in coastal erosion. For example, parts of the coastline of the Nile delta are being eroded at a rate of 240 m per year. Although the delta was eroding prior to construction of the Aswan High Dam, the higher rates of erosion observed in recent years are attributed by many to the reduction in sediment reaching the coast after closure of this dam (McCully, 1996). Similarly, erosion of parts of the Rufiji Delta, by up to 40 m per year, is attributed to the construction of dams

Source: Horrill, 1993

Figure 2 Freshwater ecosystems: Lateral, longitudinal and vertical fluxes of water, energy and material



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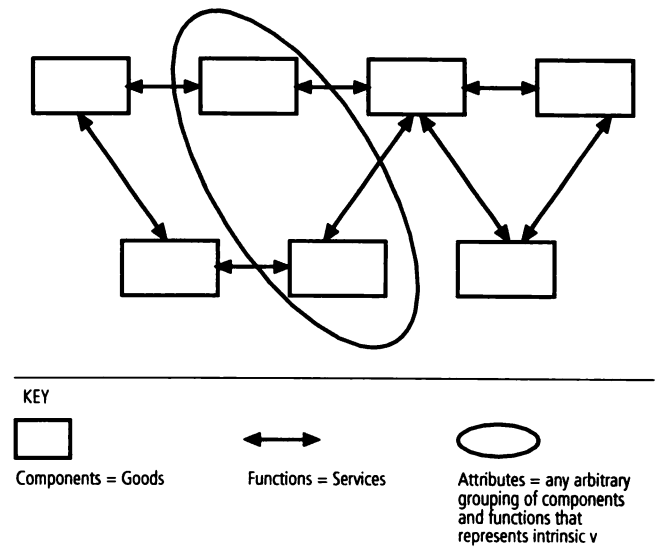
Freshwater ecosystems may be considered as structured, four-dimensional systems in which the spatial patterns of environmental variables and biological populations are determined by longitudinal, lateral, vertical and temporal gradients, linked by fluxes of water, energy and materials (see Figure 2). Although on the global scale, 'blue water' moves essentially horizontally, at smaller scales, vertical movement of water (i.e. into the ground) can be significant and groundwater must be considered a distinct, but very important, element of many freshwater ecosystems. Evaporation and freezing are important physical processes that play a key role in certain ecosystems. At the global scale, evaporation and condensation are the main forms of energy exchange between the land and the atmosphere, and thus drive the energy balance and climate of the planet.

Freshwater ecosystems comprise features that may be classified as 'components,' 'functions' and 'attributes' (see Figure 3). The components of the system are the biotic and abiotic features, which include soil and sediment, water, and aquatic organisms (i.e. microbes, macrophytes and micro-algae, riparian plants, invertebrates, fish, amphibians, reptiles, mammals and water birds). The interactions between the components comprise hydrological, biological, chemical and physical processes that result in ecosystem functions such as evaporation, respiration, photosynthesis, retention of water, nutrient transformation, productivity and habitat maintenance and development. The ecosystem itself possesses attributes, such as biodiversity, that derive from both the structure and functioning of the ecosystem. People obtain both direct and indirect benefits from all three facets of freshwater ecosystems (see section 2.3).

The integrity of an ecosystem is a measure of its 'wholeness' and its ability to continue to function in its 'natural' way. The integrity of freshwater ecosystems is a function of ecological connectivity operating across a range of spatio-temporal scales (Ward and Stanford, 1995). In this context, connectivity refers to the exchange pathways of water, resources and organisms between the different units or subsystems that comprise a freshwater ecosystem (e.g. between a river channel, its floodplain and the underlying aquifer). Flow characteristics such as duration, frequency and timing of inundation, strength of surface-water and groundwater interactions, and retention times, influence both ecosystem functions and the distribution of biota.

Fluxes of material and energy vary constantly, so ecosystems are in a constant state of change. The resilience of a system is a measure of the magnitude or scale of disturbance that can be absorbed before the system changes irreversibly in structure as a consequence of change in the variables and processes that control system behaviour. In a system of low environmental resilience, the natural processes are sensitive to change and easily altered, so that a change of relatively small magnitude may have a big impact on the biota and the processes occurring in the ecosystem. In a more resilient system, the same magnitude of change may have no, or only a minimal or

Figure 3 General relationships in freshwater ecosystems



Box 3

The value of freshwater ecosystems: The case of the Hadajia-Nguru wetlands, Nigeria

In northeast Nigeria, where the Hadejia and Jama'are rivers combine within the Komodugu-Yobe basin, an extensive floodplain of around 2,000 km² used to be inundated annually. Since 1971, a series of dams has been constructed on the main tributaries and, during recent droughts, the area inundated has reduced, with only 300 km² flooded in 1984 (Hollis et al., 1993). The dams are used primarily to provide water for cereal irrigation, and their construction was initiated partly by a ban on imported wheat which made irrigation profitable overnight. In twenty years, the Nigerian Government spent US$ 3 billion on irrigation development, though by 1991 only 70,000 ha had been farmed-making an investment of US$ 43,000 per hectare (Adams, 1992).

The yields from intensive irrigation schemes are higher per hectare than from floodplain agriculture, although the high operational costs of the schemes substantially reduce the relative benefits. However, because water resources limit the economy, it is more appropriate to express the benefits of various development options in terms of water use. Barbier and Thompson (1998) undertook an economic analysis of the Kano River, a major irrigation scheme in the headwaters of the Kano River project. They showed that the net economic benefits of the floodplain (accruing from fisheries, firewood production and recession agriculture) were at least US$ 32 per 1,000 m³ of water (at 1989 exchange rates), whereas the returns from the crops grown on the Kano River project were only US$ 0.15 per 1,000 m³. When the operational costs are included, this drops to US$ 0.0026 per 1,000 m³. Furthermore, this analysis did not take into account other benefits of flooding, such as groundwater recharge or flows downstream to Lake Chad.

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Table 1 Water use by sector (km^3/y) – first line is water withdrawal and second line is water consumption

Sector	1900	1940	1950	1960	1970	1900	1990	1995
Agriculture	525.0	891.0	1,124.0	1,541.0	1,850.0	2,191.0	2,412.0	2,503.0
	407.0	678.0	856.0	1,183.0	1,405.0	1,698.0	1,907.0	1,952.0
Industry	37.9	127.0	182.0	334.0	548.0	683.0	681.0	715.0
	3.0	9.5	14.4	24.6	38.3	61.8	72.7	79.7
Municipal needs	16.0	36.8	52.6	82.7	130.0	208.0	321.0	354.0
	3.9	9.0	13.8	20.1	29.4	41.9	53.2	57.4
Reservoir evaporation	–	–	–	–	–	–	–	–
	0.3	3.7	6.5	22.7	65.9	119.0	164.0	188.0
Total (rounded)	579	1066	1365	1985	2574	3200	3580	3760
	415	705	894	1250	1539	1921	2196	2275

Source: Shiklomanov, 1997

short-term, impact on the biota and the functions of the ecosystem. In general, resilient systems tend to be those that are physically dynamic (e.g. low-order streams), in which there is greater buffering capacity and greater potential for natural recovery.

2.3 Human appropriation of fresh water

Humans appropriate water for domestic supply, agriculture and industry. This causes 'non-natural' changes to the water budget, hydrological connections and/or quality of the water in freshwater ecosystems. Not all water withdrawn is returned to rivers, lakes or other watercourses or aquifers. The difference between the amount withdrawn and returned is called water consumption. Consumption includes water used by crops for transpiration or building plant tissue, water evaporated from land and reservoirs, and that part of the water diverted for industrial or community use that evaporates or is consumed or incorporated into a finished product. Consumed water cannot be immediately reused. Water returned to ecosystems may be polluted; warmer, cooler, richer in nutrients or heavy-metals; etc.

In the past, the effect of human activities on freshwater ecosystems was generally insignificant and of a local nature. In many cases, the natural systems had sufficient resilience to recover from the human-induced stresses placed on them. The situation has fundamentally changed during recent centuries; in many regions, the effects of human activities are evident in terms of water resource development, water use, and land-use change. In the past fifty years, increasing population, coupled with technological advances and intensive irrigation development, have had an ever-greater impact (both intentional and inadvertent) on freshwater ecosystems. Changes in water balance and water quality have resulted in environmental degradation, destruction of natural habitat and/or loss of ecological functions, with serious implications not only for the integrity of these systems but also for people's well-being.

Table 1 summarises how worldwide withdrawals and consumption have increased since 1900 for different water sectors. The irrigation sector is by far the biggest user of water, accounting for 61% of water withdrawal and 87% of water consumption. It is estimated that 30% of world food supplies are now reliant on artificial irrigation (Lanz, 1995). Industry is the second largest water withdrawal sector, followed by municipal use and the additional evaporation from reservoirs, respectively. Total global withdrawal and consumption in 1995 are estimated to have been 3,760 km^3, and 2,275 km^3, respectively (Shiklomanov, 1997).

In addition to the provision of water, freshwater ecosystems provide a wide range of other benefits for people (see Table 2). For example, freshwater ecosystems may perform natural hydrological functions that are of service to humankind. Examples include flood reduction, pollution absorption and groundwater recharge. In some instances, services are fulfilled with no need for human intervention (i.e. largely regulation of quantity and quality of water), but in other cases such services may be augmented by human interventions. Freshwater ecosystems also generate products such as forest, wildlife, fisheries and grazing resources used by humans. Ecosystem goods are products generated as components of the ecosystem. They can be either consumptive (e.g. fisheries, fodder) or non-consumptive (e.g. recreation, tourism). In addition, people also attain fewer direct benefits from the attributes of freshwater ecosystems. These include spiritual enrichment, cognitive development and aesthetic experience. Intrinsic values are those placed on the attributes of ecosystems by human society. For simplicity, in the remainder of this document the term *ecosystem services* is used to refer to both ecosystem goods and services.

Ecosystem services are of value to humans because they maintain and enhance people's well-being. Changes in the quality or quantity of services either change the benefits associated with human activities or change the costs of those activities. Generally, it is attempts to maximise benefits through the exploitation of services that result in changes to freshwater ecosystems – which, at times, decrease the total benefits provided (see Box 3).

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Table 2 Benefits to people provided by freshwater ecosystems

Services	Functions	Examples
Water supply	• Storage and retention of fresh water	52 million people draw upon the Mekong River, the longest in SE Asia, for their livelihoods (Hussain 1993). In Norway, 55,000 people use Lake Mjøsa as their drinking water source (Tollan 1992) The Edwards Aquifer in Texas, USA, is the only source of drinking water for 1.5 million people (The Trust For Public Land 1997).
Flow regulation	• Flood attenuation – Temporary storage of precipitation and runoff • Maintenance of baseflow through slow drainage of soils/groundwater	A flood prevention value of about US$ 13,500 per hectare per year has been attributed to wetlands in the catchment of the Charles River in Massachusetts (Sather and Smith 1984). In Motagua Valley, Honduras, US$ 1 million of crops produced on irrigated land depend on the dry season flow maintained by undisturbed montane 'cloud forest' (Brown et al. 1996).
Waste assimilation	• Nutrient and contaminant retention and breakdown • Heavy metal and agrochemical removal	Work in the UK indicates that denitrification may remove between 21 kg ha^{-1} a^{-1} and 44 kg ha^{-1} a^{-1} nitrate in some river marginal soils (Maltby et al. 1996). In the USA, discharges from some 300 mines are treated in artificial wetlands (McIntire et al. 1990). In Uganda, much of the sewage from Kampala is filtered by the Nakivubu wetlands.
Gas regulation/ Climate control	• Regulation of atmospheric chemical composition • Regulation of global temperature, precipitation and other biologically mediated climatic processes at global or local levels	Peat deposits occupy just 3% of the world's land area but store 16-24% of the globe's soil carbon pool (Maltby, et al. 1992). Freshwater ecosystems are important in the biogeochemical cycling of CO_2, CH_4, H_2S and N_2O (Armentano and Verhoeven 1988). For example, 40% of methane input to the troposphere comes from wetlands and rice fields (Sahagian and Melack 1996).
Goods	**Component**	**Examples**
Food production	• Portion of gross primary production that can be extracted as food (e.g. fruit, nuts, game, fish) • Retention of soil moisture during dry periods (e.g. a water reserve utilised by small-scale farmers)	Many species of edible fish breed exclusively on inundated floodplains. 100,000 tons per year are caught from the inner delta of the Niger alone (Barbier et al. 1997). In Zimbabwe, it is estimated that some 20,000 ha of seasonal wetlands, known as *dambos*, are utilised by communities of subsistence farmers (Whitlow 1984).
Power Production	• Difference in head along a river channel	Generators at Kafue Gorge hydropower station in Zambia have a capacity of 900 MW. The electricity produced (5800 GWh per year) is used both within Zambia and sold to neighbouring countries.
Raw material production	• Portion of gross primary production that can be extracted as raw materials (e.g. timber, fuelwood, grass)	In Matang Forest Reserve, Malaysia, 40,000 ha of mangroves annually yield timber worth US$ 9 million.
Recreation	• Provision of opportunities for recreational activities (e.g. tourism, water sports, hunting)	Nearly 1 million tourists visit the Florida Everglades National Park each year. Victoria Falls and the Okavango Delta are among the primary tourist attractions in Southern Africa. Visitors to Morrocy National Park in Venezuala are estimated to spend over US$ 7 million per year.
Intrinsic value	**Attribute**	**Examples**
Genetic resource	• Biodiversity	Kafue and Luena Flats, Zambia, support an outstanding diversity of organisms including over 4,500 species of plants, more than 400 species of birds and 120 species of fish (Howard 1993).
Culture	• Provision of opportunities for non-commercial use through aesthetic, artistic, educational, spiritual and/or scientific values placed on an ecosystem by human society	To millions of Hindus, the Ganges is a sacred and venerated river; Ganga Ma – Mother Ganges. The Kuomboka Ceremony among the Lozi people of the Barotse floodplain in western Zambia… The King or *Litunga*, and his people have two homes: one in the floodplain and the other on high ground. The *Litunga* and his people migrate out of the floodplain during periods of high water and back at low water.

Although the economic value of many services can be determined relatively easily, that of many others is much more difficult to ascertain. This is partly because the contributions to human welfare by ecosystem services are often in the nature of public goods. They are accrued directly by humans without passing through the money economy at all. In many cases people are not even aware of them. In other cases, the benefits accrued are indirect and associated with qualitative human aspirations (e.g. aesthetic appeal) to which it is very difficult, and many would argue impossible, to attach a monetary value. However, economists are attempting to develop methods of true economic valuation. For example, multi-criteria analysis is a method designed to take into account both quantitative and qualitative data, including non-monetary variables (Barbier et al., 1997).

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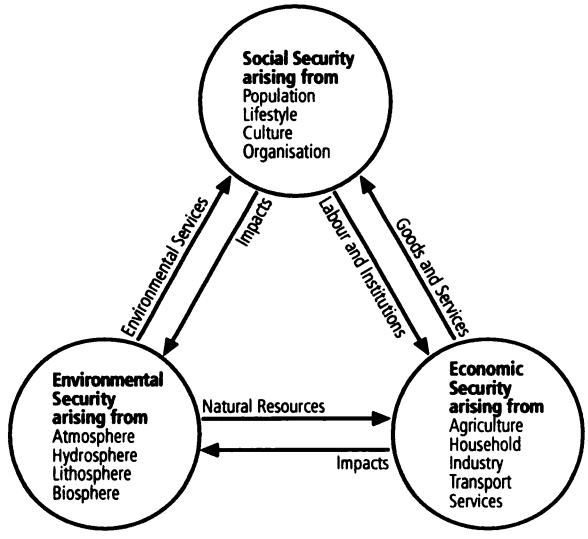
2.4 Environmental security

Environmental security is an ambiguous term, which means different things to different people. However, essentially it is about improving human well-being by making the most appropriate use of the planet's natural resources and functions. It is a key tenet of this paper that, within the context of freshwater ecosystems, this is best achieved by maximising the long-term benefits to be gained from all aspects of freshwater ecosystems.

Environmental security is an integral element of human security (Graegar, 1996). It is linked to both economic and social security, and so may be conceptualised as a cornerstone of the tripartite system of global security (see Figure 4).

Figure 4 Components of global security



Adapted from Raskin et al., 1996

Reduction of environmental security reduces both economic and social security and, conversely, reduction in either social or economic security can result in reduction in environmental security. A decline in environmental security may initiate a downward spiral of poverty and environmental degradation. Loss of environmental security, through environmental degradation or poor respect for environmentally-attuned resource management, may result in, or at least exacerbate, social unrest. In extreme cases, decreasing environmental security may be a contributing factor causing armed conflict (Homer-Dixon, 1994).

Different benefits are accrued by people from 'natural' and 'altered' freshwater ecosystems (see Figure 5). A wetland that is only slightly disturbed by human activities is a near-natural system that, as discussed above, may provide services which contribute to the economic, social and environmental security of society. The benefits accrued by those people living close to the wetland may be greater than those gained by people living further away.

A reservoir is an example of an altered or 'non-natural' system, which provides economic, social and environmental security to those people in society who benefit by using the water it provides. However, in converting a natural system into a non-natural system, there is a trade-off between benefits gained and lost (see Figure 6). This occurs because human-induced change in an ecosystem always has a derogatory effect on some natural functions, thereby undermining the services to some people. For example, dams disrupt the natural flow regime of rivers downstream. They often reduce flood peaks, and hence the frequency, extent and duration of floodplain inundation, which may in turn reduce opportunities for recession agriculture and so reduce the benefits accrued by people living in the vicinity of the floodplain (see Box 3).

Figure 5 Natural and non-natural ecosystem benefits

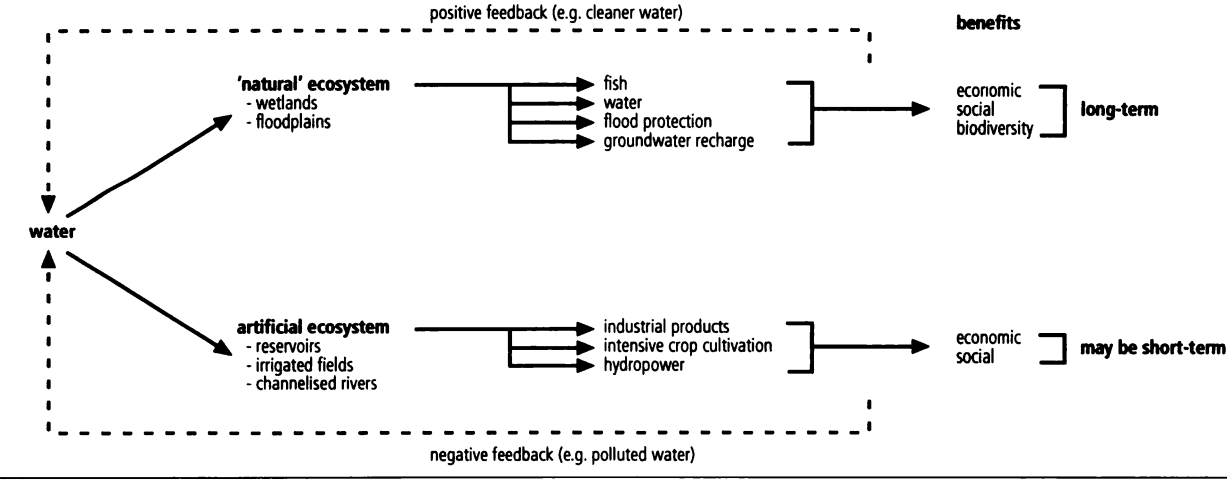


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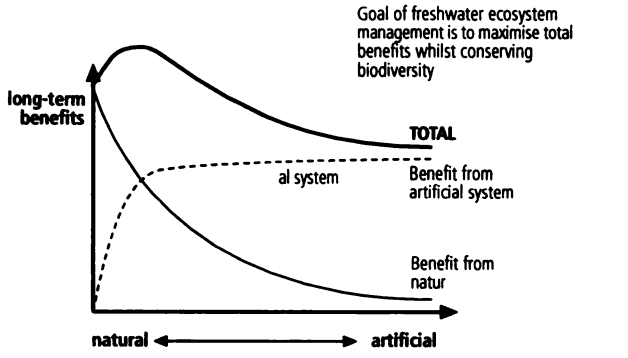
Figure 6 Maximising benefits from freshwater ecosystems



It is possible that benefits gained from a non-natural system are large in the short-term but decrease in the long-term. For example, the benefits provided by a reservoir while initially high will decrease over time if it fills with sediment and the amount of water available for human use decreases. Hence, long-term sustainability, and the ideal of maintaining options for future generations, is a key consideration in the context of environmental security. It is believed by many people that benefits gained from natural systems are sustainable over the long-term while those gained from very modified systems are not. However, evidence suggests that systems far from their natural state can be sustainable over the long-term if they are correctly managed. Thus, for example, reservoirs may be sustainable if sediment flushing is introduced into their operation, or the catchments in which they are located are managed to reduce soil erosion and sediment transport into the reservoir. Furthermore, it may be possible to sustain downstream ecosystems by artificial flood releases (see section 5.3.1).

In addition to changes in the balance of benefits to human society that occur when a natural system is altered by people, human-induced change also affects the natural biota. For example, dams directly and indirectly influence a myriad of dynamic factors (i.e. not just flow regime but also sediment and chemical transport, etc.) that affect habitat heterogeneity and successional trajectories and, ultimately, the ecological integrity of freshwater ecosystems. In a comparison of two floodplains of the Danube, one disconnected from the channel and the other with the connectivity largely in tact, Löffler (1990) documents much greater diversities of macrophytes (60 versus 20 species) and fishes (30 versus 4 species) on the unaltered site.

Another aspect often associated with environmental security is what might be called 'ethical security.' This is the growing belief, of many people, that humans have a moral duty to protect wildlife. In the context of freshwater ecosystems, this means provision of adequate water (both quantity and quality) to maintain indigenous flora and fauna. The idea that the natural environment has a right to water per se was taken up by the United Nations (UN) in 1982, when the governments of the UN made an ethical commitment to nature in the form of The World Charter for Nature. This expresses absolute support by governments of the principles of conserving biodiversity. It recognises that humankind is part of nature, that every form of life is unique and warrants respect regardless of its worth to human beings, and that lasting benefits from nature depend on the maintenance of essential ecological processes and life-support systems and upon the diversity of life forms (McNeely et al., 1990). In a sense, this is environmental conservation in its purest form. Often termed 'deep ecology' it promotes conservation of ecosystems as a public good, independent of their utility as a resource.

Throughout the literature, environmental security is used as a broad concept encompassing all the issues discussed above. It can therefore be conceived as a broad paradigm that:

- recognises that the Earth's ecosystems should be maintained or enhanced where they are degraded, so that they yield the greatest sustainable benefit to present generations while maintaining the potential to meet the needs and aspirations of future generations;
- recognises the need to protect humans from natural hazards;
- recognises the environment as a legitimate user of water;
- recognises that scarcity or inequitable distribution of natural resources (both in terms of quality and quantity) can often be the cause of conflicts in society.

In any given set of circumstances, the emphasis may be placed, by different people, on any one of the aspects listed above. Thus, the precise meaning varies depending on who is using it and in what context. In this paper, in an attempt to incorporate all the elements listed above, we use the following sweeping definition:

> *Environmental security is that aspect if human well-being determined by the state of ecosystem resources and functions. The level of environmental security affects the extent to which the social aspirations, economic goals and ethical commitments of both present and future generations can be met.*

It acknowledges the fundamental linkages between environmental security and management, economic development and the social well-being of people.

From the preceding discussion of environmental security, it is clear that there are complex interrelationships between humans and the natural environment. Today, as discussed in section 3, various driving forces and human-induced pressures are increasing the competition for scarce water resources and causing a reduction in environmental security, across the entire spectrum of the term. Management is required to balance the different and competing demands placed on freshwater ecosystems. The need to balance human requirements for fresh water and freshwater ecosystem services against ecosystem capabilities and constraints is made more complicated by the additional need to take into account societal preferences about the manner in which ecosystems are utilised. There is no baseline state against which to determine the 'condition' of a natural freshwater ecosystem so 'desired' states must be determined by society.

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3. Problem identification and analysis

Our numbers are burdensome... the world can hardly supply us from its natural elements... our wants grow more and more keen, our complaints more bitter, while nature fails in affording us her sustenance (Tertullian, Rome, 160-230AD).

Human-induced pressures are causing changes in the state of freshwater ecosystems and leading to localised resource scarcity. However, the severity and consequences of these changes for humankind are still widely debated. There are two extreme positions. First, there are those, often biologists or ecologists, who claim that finite natural resources place strict limits on the growth of the human population and consumption; if these limits are exceeded, poverty, social breakdown and ecosystem degradation result. Second, there are those, mainly neoclassical economists, who argue that there need be few, if any, strict limits to human population, consumption or prosperity, because human ingenuity is such that resource substitution, the development of new resources, technological innovation and improved management will enable humans to surmount scarcity and improve their lot (Homer-Dixon, 1995).

A prerequisite to resolving this debate is an understanding of the extent to which human interventions are altering ecosystems and their functions, and quantification of how this affects environmental security. Against this background, this chapter aims to:

- describe the problem of unsustainable utilisation of freshwater ecosystems;
- discuss the underlying causes of human degradation of these systems;
- identify the principal anthropogenic pressures exerted on freshwater ecosystems;
- review evidence of changes in the state of freshwater ecosystems and different aspects of environmental security related to freshwater ecosystems.

The issues are discussed as a series of themes. The interaction of humans with the environment is complex and, wherever possible, indices are used to provide summary or surrogate information. There are problems with all the indices used (as a consequence of data scarcity and/or definition of terminology); nevertheless, they assist in making the complex phenomena discussed more perceptible.

3.1 The problem: Unsustainable utilisation of fresh water and environmental change

All natural ecosystems experience change as a consequence of natural phenomena. However, today, human interventions are causing unprecedented rates of change and the Planet's natural resources are being exploited in a manner that many argue is largely unsustainable. Since the industrial revolution, there has been a dramatic increase in population and resource use. The consequences of human exploitation of the environment are observable throughout the world in the form of decline in the quantity and/or quality of renewable resources which is occurring faster than natural processes renew them. At present, water pollution, falling water tables, soil erosion, destruction of ecosystem functions and loss of wildlife habitat are widespread. The direct threats to freshwater ecosystems result from physical, chemical or biological changes in the environment. Examples of physical changes include dam construction and changing the land-use within a catchment. Chemical changes include changing water salinity, increasing the organic loading, and/or increasing nutrient content or levels of toxic material in the water. Biological changes include overexploitation of fish, changes arising from grazing and introduction of exotic species (see Box 4).

The spectacular increase in the scale of global water withdrawals is illustrated in Table 3. Since 1900, total water extraction has increased by a factor of 6.5 as a result of both population increase (a factor of 3.4) and water use per capita (1.9). Although at first sight the estimated total freshwater withdrawal (i.e. 3,760 km^3), which accounts for only about 9 per cent of the total average annual runoff (40,000 km^3), appears not to be a serious problem, the resource situation is actually a lot more critical than these figures indicate. There are three reasons for this:

- a large proportion of the total runoff occurs in the form of floods and is currently largely inaccessible to humankind;
- humans do not just make withdrawals but also utilise water for a range of instream uses (e.g. navigation, recreation, waste assimilation, etc.);
- global averages mask large spatial and temporal variance of freshwater resource and requirement patterns. Episodic water scarcity occurs even where time-averaged resources appear adequate.

Table 3 Global trends in freshwater withdrawal

	1900	1950	1995
World population (billion)	1.6	2.5	5.5
Water withdrawal per capita (m^3/y)	360	550	680
Water withdrawal total (km^3/y)	580	1,365	3,760

Source: Shiklomanov, 1997

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If allowance is made for the fact that not all water is currently available for human exploitation, then it has been estimated that humans currently appropriate (i.e. withdrawals plus in-stream use) some 54% of the planet's accessible 'blue water' and some 26% of 'green water' (see Box 5). Increasing population, in conjunction with increased degradation of freshwater ecosystems, is making water increasingly scarce in relation to potential demand. There are increasing social tensions and conflicts due to growing water scarcities and higher wastewater discharges in many parts of the world.

Even where human utilisation does not consume fresh water, human activities may disrupt the dynamic hydrological regime of ecosystems and patterns of connectivity. For example, dams not only consume water through promotion of evaporation, but also disrupt the downstream river system's natural disturbance regime. Reduction of flood peaks reduces the frequency, extent and duration of floodplain inundation. Reduction of channel-forming flows reduces channel migration. Truncated sediment transport typically results in channel degradation below the dam and a concomitant lowering of the water table (Ward and Stanford, 1995). These changes, and others, directly and indirectly influence a myriad of dynamic factors that affect the ecological integrity of downstream freshwater ecosystems. These changes can have severe consequences for people who rely on the systems for their well-being.

As discussed in section 2.4, when freshwater ecosystems are altered by people, although there may be short-term gains in environmental security for some people, over the long-term there may be a net reduction in environmental security as a consequence of loss or decline in the quality of services provided by the ecosystem in its natural state (see Box 6). Even where there is no immediate impact on the social and economic well-being of society, human-induced change may have a deleterious impact on wildlife habitat, causing the destruction of flora and fauna which cannot adapt to the altered environment. It should be remembered that the use and misuse of water in one location can have far-flung effects, altering downstream resources, water quality and aquatic ecosystems (see Box 7).

Box 4 Lake Victoria

Lake Victoria: Consequences of the Introduction of Nile Perch

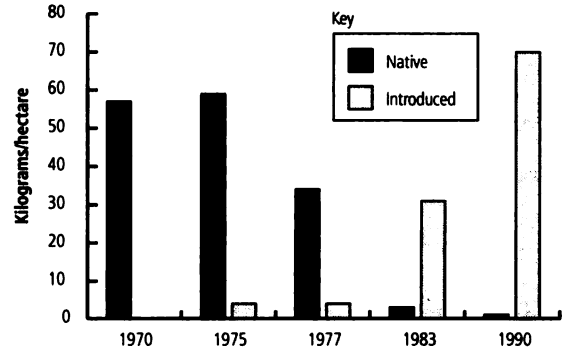
The Great Lakes of East Africa are home to vast numbers of cichlid fish species. Because the largest lakes (Lake Malawi, Lake Tanganyika and Lake Victoria) are not connected to each other and lie in different catchments, each one's fauna and ecology are distinct; 99% of the species found in each Lake are endemic.

Lake Victoria, covering some 62,000 km², is the largest lake in Africa and the second largest lake in the world. Nile Perch were introduced into the Lake in 1954 to improve the local fishing industry. Nile Perch which may grow to 200 kg, are predators that consume enormous quantities of small fish. Since the perch was introduced, Lake Victoria has lost 200 taxa of endemic cichlids and the remaining 150 are listed as endangered.

The exact reason for the relative success of the perch is uncertain, but the perch's ability to alter its lifestyle and breeding strategy to suit prevailing conditions may play a significant role. In the late 1970s, the lake's water began to undergo eutrophication (see section 3.4.2). At the same time, the perch underwent a massive population explosion and quickly began displacing native fish. The results are apparent from fishery statistics. Kenya, for example, reported only 0.5% of its commercial catch as perch in 1976, but by 1983 the proportion reached 68%. While a small proportion of that increase may be attributed to larger fishing vessels and more fishers, scientific surveys also show the demise of the native fish and takeover by introduced fish species.

Impact of introduced species: The demise of native fishes of Lake Victoria

Impact of introduced species: the demise of native fishes of Lake Victoria



Source: Abramovitz, 1996

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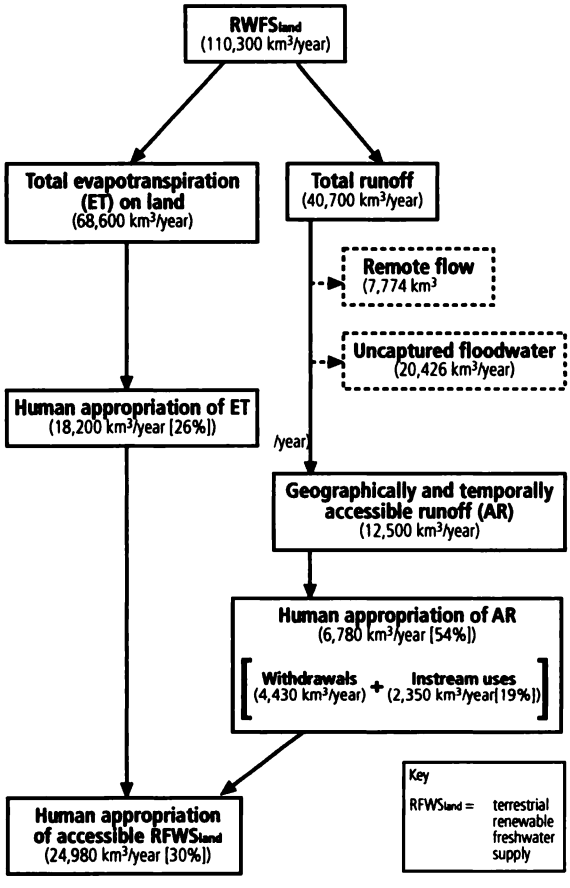
Box 5 Appropriation

Human appropriation of water

It is estimated that of the total runoff, 12,500 km³ y⁻¹ is at present geographically and temporally accessible to humans and of this, 2,285 km³ a⁻¹(i.e. 18%) is consumed directly for human purposes and another 4,495 km³ y⁻¹ is used for anthropogenic in-stream uses (e.g. maintenance of navigation paths, dilution of wastes, fisheries and recreational opportunities). Thus, it is estimated that a total of 6,780 km³ y⁻¹, or 54% of accessible 'blue water' is appropriated for human use.

In addition it is estimated that cultivated land co-opts 18,200 km³ y⁻¹ (i.e. 26%) of the total 'green water' (i.e. 69,600 km³). This is after subtracting the share provided by irrigation water (2,000 km³), to avoid double accounting. The remaining 74% of total terrestrial evapotranspiration must meet the water needs of all other land-based vegetation.

Thus human appropriation of water is estimated to be 24,980 km³ y⁻¹ (i.e. 30% of accessible renewable freshwater supply, $RFWS_{land}$ and 23% of total $RFWS_{land}$).



Source: Postel et al., 1996

Box 6 Senegal River

Senegal River: An example of reduction in environmental security resulting from mis-management of water resources

In the Senegal River Basin, past floodplain farming, herding and fishing was dependent on the river's annual floods. However, in the 1970s, concern about food shortages and drought led the governments of the region to seek financing for the Manantali Dam on a tributary, and the Diama barrage near the mouth of the river. These dams were designed to regulate the river's flow with the multiple aims of producing hydropower, expanding agriculture and increasing river transport. However, the plan had unforeseen consequences. In anticipation of increased land values along the river, the Mauritanian elite, comprising mainly white moors, rewrote legislation governing land ownership – effectively preventing black Africans from continuing traditional flood-based activities along the river. This resulted in ethnic violence in both Senegal and Mauritania. In Senegal, almost all of the 17,000 shops owned by Moors were destroyed, and their owners were deported to Mauritania. In Mauritania, some 70,000 black Mauritanians had property confiscated and were forcibly expelled to Senegal. Several hundred people were killed and the two countries almost went to war. Although diplomatic relations have now been restored, neither country has agreed to allow the expelled population to return or to compensate them for their losses.

Source: Homer-Dixon, 1994

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Box 7 Aral Sea

Aral Sea: An example of reduction in environmental security resulting from mismanagement of water resources

The Aral Sea is one of the planet's greatest environmental disasters. Prior to 1960, an average of 55 billion cubic metres of water flowed into the Aral Sea, then the planet's fourth-largest lake, from the Amu Dar'ya and Syr Dar'ya. However, abstraction for cotton irrigation and the construction of flood storage reservoirs resulted in a decline in average annual inflow to 7 billion cubic metres between 1981 and 1990. This has resulted in a catastrophic regression in sea levels (16 m between 1962 and 1994) and a total decline in volume of three-quarters. Twenty of the 24 species of fish that used to be present in the sea have disappeared, and the fish catch that totalled 44,000 tons a year in the 1950s and supported 60,000 jobs has dropped to zero. There has been a drastic reduction in terrestrial biotic diversity on the floodplains of the Amu Dar'ya and Syr Dar'ya. Toxic dust-salt mixtures picked up from the dry seabed and deposited on surrounding farmland are harming and killing crops. The low river flows have concentrated salts and toxic chemicals, making water supplies hazardous to drink and contributing to the high rate of many diseases in the area. The population of Munyak, a former fishing town, has dropped from 40,000 several decades ago to just 12,000 today. The 28,000 people who have left are 'ecological refugees;' their environmental security has been eroded to such an extent that they have moved.

Source: Zaletaev, 1995; Postel, 1996

3.2 Underlying causes of decreases in environmental security (a conceptual model)

Given that the benefits that people accrue from freshwater ecosystems are now broadly understood, the question arises: why is it that management policies which result in a net decrease in environmental security continue to occur? The reasons are complex and result from the interaction of environmental, social and economic issues. A detailed analysis is beyond the scope of this paper, but in summary, it arises mainly for three reasons:

- Insecurity in the socio-economic corners of the human security system outweigh the need to maintain environmental security. Long-term environmental security is sacrificed because of the need to maintain or re-establish security in the other corners of the tripartite system. Desperate people will often focus on immediate survival strategies and neglect the long-range value of ecological preservation. "To care about the environment requires at least one square meal a day" (R.Leakey, ex-Director of the Kenya Widlife Service – cited in Simonovic, 1996)).
- As a result of inappropriate and ill-informed decision-making, there is a tendency to focus on the benefits that alteration of ecosystems bring to certain people in society and not others. For example, catchments are often managed to maximise the benefits to be gained by the urban population while neglecting the rural populations. Furthermore, the focus is very often on short-term gain rather than long-term benefits.
- When environmental problems occur, existing management strategies often focus on technical solutions that consider only certain parts of the total system. Such 'engineering solutions' are implemented mostly as end-of-pipe measures (e.g. emission restrictions for the discharge of pollutants to receiving waters) to directly meet the experienced environmental problem (concerning water quantity or quality). Dynamics and interactions are investigated only in the small, local system under consideration.

The relations between society and the environment are poorly understood. However, a simple conceptual model of the way social, economic and ecological subsystems interlink and interact is presented in Figure 7. This provides a framework in which to consider management strategies and the implications of management decisions for ecosystems. The model assumes that the current state of ecosystems is subject to pressures that are brought about as a consequence of global driving forces. The state of any ecosystem describes its condition, and is dependent on the pressure and vulnerability of the system. Thus, pressures cause changes in the state of ecosystems. In turn, the state of ecosystems at any given time impacts the social and economic well-being of people and so affects environmental security. Impacts result in responses from society, which in turn effect either the driving force or the pressures affecting a freshwater ecosystem. Thus, societal responses introduce feedback into the system. By modifying human response, it is possible to alter the impact on freshwater ecosystems. Ecosystem management strategies seek to identify mechanisms by which human interaction with the environment can be changed so as to enhance the long-term benefits not just of people but also of the other species reliant on the ecosystems (see section 5).

Table 4 presents various aspects of freshwater ecosystem interactions, divided into the classes defined within this conceptual model. It is a somewhat subjective division, illustrating the complex nature of interactions and the difficulty of pigeon-holing different aspects in the various classes of the model. For instance, dam building can be viewed as either a pressure or a response – an example of the feedback in the system.

The driving forces are socio-economic, and are discussed in detail in the other papers in this series (Swanson and Doble, 1999; Soussan et al., 1999). In the current paper, we simply note that human population growth is the fundamental pressure underlying all others. At present, the world population of 6 billion is estimated to be growing at just under 1.5% y^{-1} (ca 80 million a year). Growth rates of some of the world's most populous countries are hardly declining at all. India's rate has levelled off at around 2.1% (17.9 million people), China's at around 1.3% (14.8 million people) per year. The mid-range projection from the United Nations is that world population will grow to about 8.3 billion in 2025, 9.4 billion by 2050, and will probably stabilise towards the end of the 21st century at about 11 billion (Engleman and LeRoy, 1993).

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Figure 7 Simple conceptual model of interaction within social-economic-environmental systems, highlighting the mitigation and adaptation feedback strategies of management

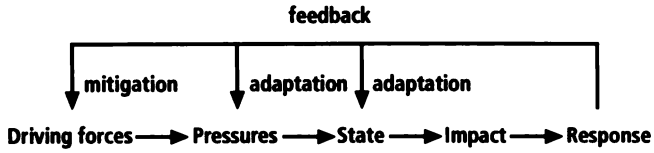

Table 4 Conceptual model for assessing causes and implications of change in freshwater ecosystems. The driving forces may cause any combination of pressures which in turn may induce any of the states, impacts and responses. More than one driving force/pressure may contribute to any particular state/impact/response.

Examples of Driving Force	Examples of Pressures	Examples of Affected State	Examples of Impact	Examples of Responses
Increasing population and mobility		Degraded wetland habitat		Stricter birth control
	Overexploitation of natural resources		Loss of ecosystem functions	
Increased expectation		Degraded headwater forests		Demand management
	Increase in irrigation		Inequity in access to land and water resources	
Globalisation of world economies and continuing economic growth		Decreased quality of fresh water		Increasing expenditure on technical fixes
	Dam construction		Increased social conflict	
Industrial development		Decreased biodiversity		Conferences/ workshops
	Increased abstraction		Increased incidence of disease	
Burning of fossil fuels		Changed rainfall		Ecosystem restoration
	Increased effluent discharge		Increased exposure to environmental hazards (e.g. floods)	
Technological innovation				Immunization programmes
	Eutrophication		Increased water scarcity	
				Construction of flood defence walls
	Climate change			

3.3 Indicators of human-induced pressures on freshwater ecosystems

In this section, the human-induced pressures placed on freshwater ecosystems are investigated. In many cases, the pressures on freshwater ecosystems can only be ascertained indirectly. Data are sparse and problematic because descriptions and data collected vary from country to country. Hence, the themes and indices presented in this section are an illustrative rather than a definitive compilation.

3.3.1 Land-cover transformation

Worldwide human-induced changes to land-cover represent perhaps the most significant direct threat to natural freshwater ecosystems. Changes in land-cover cause changes in the energy and material fluxes that support freshwater ecosystems. It has been shown that conversion of forest cover to agriculture may alter the radiation balance of the surface, soil structure, evapotranspiration and runoff generation (e.g. Gash et al., 1996). For example, results of simulations using a global circulation model, in which Amazon tropical forest and savannah were replaced by pasture, predicted a weakened hydrological cycle with less precipitation and evaporation and an increase in surface temperature as a consequence of changes in albedo and surface roughness (Lean and Warrilow, 1989). Rainfall was reduced by 26 per cent for the year as a whole (Shukla et al., 1990). However, the impact on an individual freshwater ecosystem depends on the specific nature of interventions, the scale of the land cover change, and the interplay of site-specific factors such as soil type, geology and slope with the local climate. It is therefore not possible to predict the consequences of specific land-use change for freshwater ecosystem integrity.

In this report, two indicators are used to show broadly the pressure of land use change on freshwater ecosystems. These are a change in the proportion of agricultural land and the change in proportion of forest cover. Since it will not support either forests or agriculture, the area of the Antarctic was subtracted from the total land area of the planet when calculating the global indices.

Figures 8 and 9 present the trends in these two indices for different regions of the world, for the period 1961 to 1991. The indices show that, worldwide, the proportion of the land surface given over to agriculture increased from 0.33 to 0.37, and there was a worldwide decline in forest cover from 0.33 to 0.32 between these dates. However, the data indicate that, in developed countries, there has been a decrease in the proportion of land used for agriculture and an increase in forest cover. This occurs particularly in Europe, where the proportion of land used for agriculture decreased from 0.49 in 1961 to 0.45 in 1991, and over the same period the proportion of forest cover increased from 0.29 to 0.32. This almost certainly reflects change in agricultural policy within Europe (e.g. set aside) and the increase in plantation forests (i.e. non-native species) in this region. In Europe, primeval forest coverage

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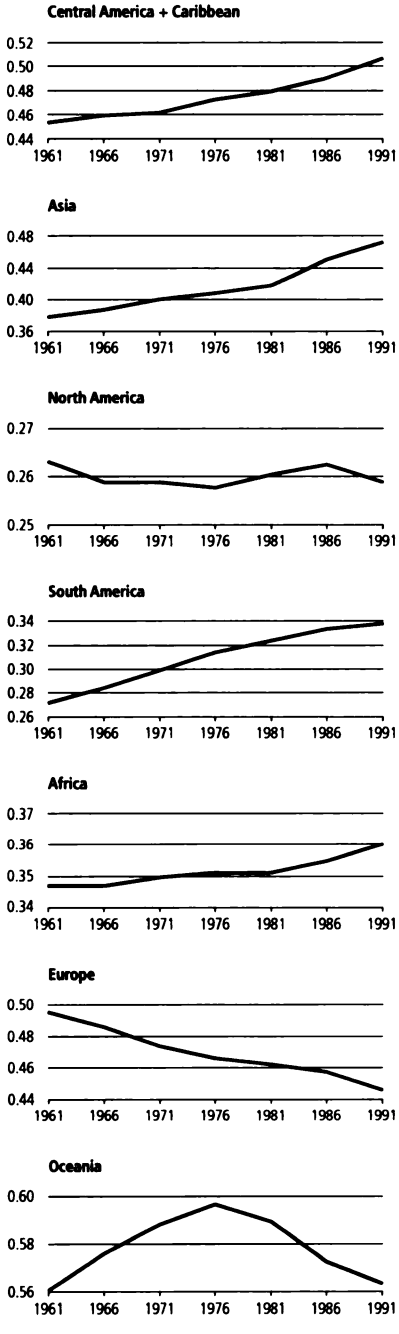
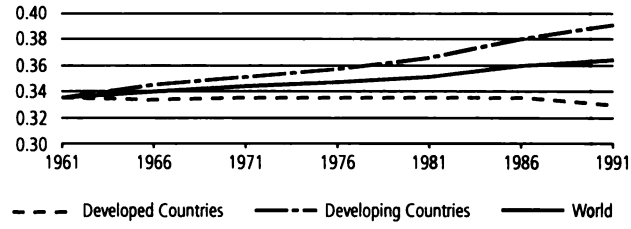
Figure 8a Change in the proportion of agricultural land by continent (1961-1991)



Source: FAO, Waicent database

Figure 8b Change in the proportion of agricultural land in developed and developing countries (1961-1991)



Source: FAO, Waicent database

continues to decline (DVL/OS, 1997). Hence, increases in forest cover and decreases in agricultural land do not, in themselves, necessarily indicate a decrease in the pressure on freshwater ecosystems.

3.3.2 Dam construction

Reservoirs store surplus wet-season runoff for use in dry periods or when required for hydropower production. It is estimated that, worldwide, there are currently some 40,000 large dams (i.e. >15 m high) and more than 800,000 smaller ones[1]. More than 400,000 km² (0.3% of the global land surface) has been inundated by reservoirs and it is estimated that reservoirs have an aggregate storage capacity of about 6,000 km³ (McCully, 1996; Le Cornu, 1998). The volume stored represents about a seven-fold increase in the standing supply of natural river water (Vorosmarty et al., 1997).

Dams have been an influential part of human development over many centuries and are essential for the well-being of millions of people throughout the world. However, because dams constitute obstacles for longitudinal exchange along river systems, they can have significant environmental impacts. The most obvious effect of storage reservoirs is the permanent destruction of terrestrial ecosystems through inundation. Downstream ecosystems are effected as a consequence of changes in flow regimes, sediment transport and water temperature and quality. Dams may cause changes in freshwater and even marine ecosystems a long way downstream from where they are built. These changes can have severe implications for flora and fauna. For example, it is estimated that half the fish stocks endemic to the Pacific coast of the USA have been wiped out in the past century, often because of dam construction (Chatterjee, 1998). The responses of ecosystems to dams are multiple, varied and complex. They depend not only on the dam structure and its operation, but also on local sediment supplies, geomorphic constraints, climate, and key attributes of the local biota.

1. The demarcation between large and small dams, made by the International Commission on Large Dams (ICOLD), is based purely on engineering criteria. The differentiation does not represent a critical parameter in assessing the social and environmental impact of dams.

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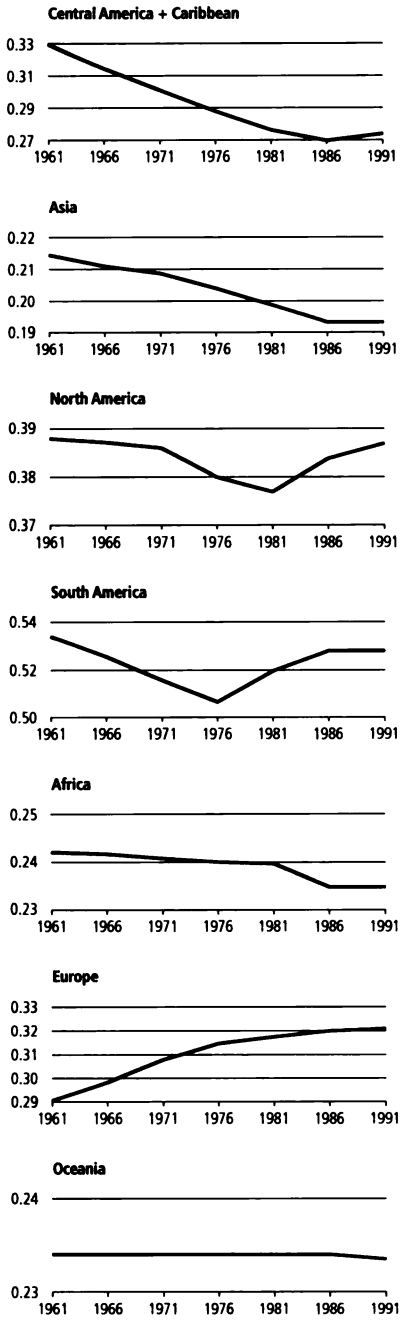
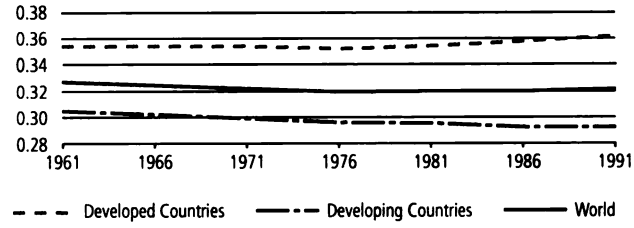
Figure 9a Change in the proportion of forest cover by continent (1961-1991)



Source: FAO, Waicent database

Figure 9b Change in the proportion of forest cover in developed and developing countries (1961-1991)



Source: FAO, Waicent database

Since the mid-1980s, as the value of natural ecosystems to human society has become more widely understood (see section 2.3), a well-organised international movement against current dam building practices has evolved. The principal argument of opponents of dams is that existing dams have largely failed to meet their economic and social objectives, and at the same time resulted in considerable environmental damage. They argue that the environmental security of millions of people is undermined either as a consequence of dam failure (see Table 5) or because they are displaced by the reservoir flooding (see Table 6). In the tropics, dams and associated infrastructure are often linked to declines in health through increased malaria, schistosomiasis and other vector-borne diseases (see section 3.5.3) that require water (Jobin, 1999). Furthermore, changes in ecosystems can have negative impacts on the livelihoods of people who depend on ecosystems affected by dam construction. Hence, dams can undermine not only environmental but also social and economic security.

Conversely, dam proponents maintain that in many instances the negative impacts of dams, both on the environment and human well-being, have been overstated. They argue that the benefits of dams (e.g. guaranteeing water supply, protection from floods (but see section 3.5.4) and the development of new habitats that benefit some flora and fauna) outweigh the negative impacts. While it is generally accepted that environmental issues have played little part in the design and specification of operating rules of many dams in the past, they argue that current environmental standards (e.g. World Bank, 1999) ensure that in future negative environmental and socio-economic impacts will be minimised. There are many ways in which the impacts can be mitigated. For example, new dams can be located at sites where environmental and social impacts are reduced. With careful design and careful environmental manipulation, the negative health impacts can often be avoided. Some mitigation measures (e.g. changing dam operation to maintain environmental flow requirements) can, in certain circumstances, be implemented after a dam has been built. Furthermore, dam proponents argue that many of the alternatives to dams are at present either uneconomical (e.g. desalination), impractical or more environmentally damaging (e.g. thermal and nuclear power stations).

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Table 5 Dam disasters in which 1,000 or more people have been killed †

Dam	Country	Height (m)	Year failed	Cause of failure*	People killed
Iruhaike	Japan	28	1868	OT	>1,000
South Fork (Johnstown)	USA	13	1889	OT	2,209
Tigra	India	24	1917	OT	>1,000
Oros	Brazil	54	1960	OT	ca. 1,000
Panshet/Khadakwasla +	India	54/42	1961	SF, OT/OT	> 1,000
Vaiont	Italy	261	1963	OT	2,600
Banqiao, Shimantan, 60 others	China		1975	OT	≤230,000
Macchu II	India	26	1979	OT	> 2,000

Source: modified from McCully, 1996

+ The flood from the collapse of the first dam breached the second dam downstream
* OT = overtopping, SF = structural failure
† The average worldwide risk of any dam failing in any given year is estimated to be 1 in 10,000 and it is thought there were '200 notable reservoir failures' between 1900 and 1980 (McCully, 1996).

Table 6 Examples of numbers of people displaced as a consequence of the construction of large dams

Project name	Country	Megawatts	Area flooded (ha)	No. of people displaced	No. displaced/ MW
Three Gorges	China	18,200	110,000	1,300,000	71
Itaipu	Brazil/Paraguay	12,600	135,000	59,000	5
Guri Complex	Venezuela	10,300	426,000	1,500	0
Tucurui	Brazil	7,600	243,000	30,000	4
Grand Coulee	USA	6 494	33,306	10,000	2
Churchill Falls	Canada	5,225	665,000	0	0
Tarbela	Pakistan	3,478	24,280	96,000	28
Ertan	China	3,300	10,100	30,000	9
Ilha Solteira	Brazil	3,200	125,700	6,150	2
Yacyreta	Argentina/Paraguay	2,700	172,000	50,000	19
Ataturk	Turkey	2,400	81,700	55,000	23
Bakun	Malaysia	2,400	70,000	9,000	4
Tehri	India	2,400	4,200	100,000	42
Aswan High	Egypt	2,100	400,000	100,000	48
Cabora Bassa	Mozambique	2,075	380,000	250,000	120
Ghazi Barotha	Pakistan	1,450	2,640	899	1
Sobradinho	Brazil	1,050	415,000	65,000	62
Narmada Sagar	India	1,000	90,820	80,500	81
Mangla	Pakistan	1,000	25,300	90,000	90
Akosombo/Volta	Ghana	833	848,200	80,000	96
Kainji	Nigeria	760	126,000	50,000	66
Nam Theun 2	Laos	600	34,000	4,500	8
Pehuenche	Chile	500	400	10	0
Arun III	Nepal	402	43	775	2
Khao Laem	Thailand	300	38,800	10,800	36
Balbina	Brazil	250	236,000	1,000	4
Victoria	Sri Lanka	210	2,270	45,000	214
Nam Thuen-Hinboun	Laos	210	630	0	0
Nam Ngum	Laos	150	37,000	3,000	20
Pak Mun	Thailand	34	6,000	4,945	145
Kedung Ombo	Indonesia	29	4,600	29,000	1,000
Kompienmga	Burkina Faso	14	20,000	1,842	132

Source: IUCN, 1997

Figure 10 illustrates three indices that can be used to assess the pressure of dams on freshwater ecosystems. These relate to:

- The number of dams per kilometre of river – an indicator of the fragmentation of river ecosystems as a consequence of dam construction. Figure 10a would suggest that, of the rivers illustrated, the Danube is the most fragmented river system.
- The total gross reservoir capacity compared to mean annual discharge – an indicator of the control the dams have over the flow regime of the river, and consequently the potential for natural hydrology to have been altered. Figure 10b shows that on the Nile, Zambezi and the Colorado, the gross reservoir storage exceeds the mean annual runoff, indicating highly-controlled flow regimes.
- The number of large dams in relation to the total area of a country – an indicator of national differences in dam construction. Figure 10c shows that there is considerable international variation in this index, with South Korea having the most dams per square kilometre.

It is important to note that the overall effect of a dam on the integrity of an ecosystem is a function not only of its size relative to the flow of water in the river, but also of the way in which it is operated and the physiographic characteristics of the catchment in which it is built. There appear to be some inconsistencies in the data available. For example, for the River Elbe there are no entries of large dams on the ICOLD database, but Dynesius and Nilsson (1994) record gross reservoir storage of 5 Mm^3. Hence, either this storage is entirely within reservoirs not classified as large by ICOLD (i.e. dams less than 15 m high), or the ICOLD database is lacking information for the Elbe[2].

The dam debate encapsulates many of the issues most relevant to the management of freshwater ecosystems in general, and the requirement to balance the need for human development while at the same time maximising long-term human well-being and security. Central to the debate is the question of whether in the long-term dams are useful or detrimental; whether they provide a net improvement to human well-being or whether they spoil it. The World Commission on Dams (WCD) is currently conducting an objective review of the overall costs and benefits of large dam projects. It has a mandate to assess the experience of existing, new and proposed large dam projects so as to improve (existing) practices, social and environmental conditions, and to develop decision-making criteria, policy and regulatory frameworks for assessing alternatives for energy and water resources development. It also aims to develop and promote internationally acceptable standards for the planning, assessment, design, construction, operation and monitoring of large dam projects and, if the dams are built, to ensure that affected peoples are better off.

2. The ICOLD database has information on 25,410 of the Worlds estimated 40,000 large dams, but does not include geo-referenced locations or the gross or net storage of water within reservoirs created.

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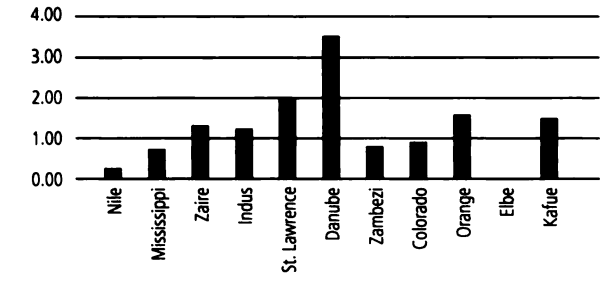
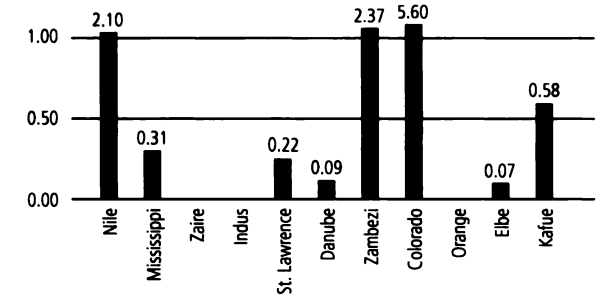
Figure 10 Different indices used as indicators of pressure caused by dams on freshwater ecosystems.

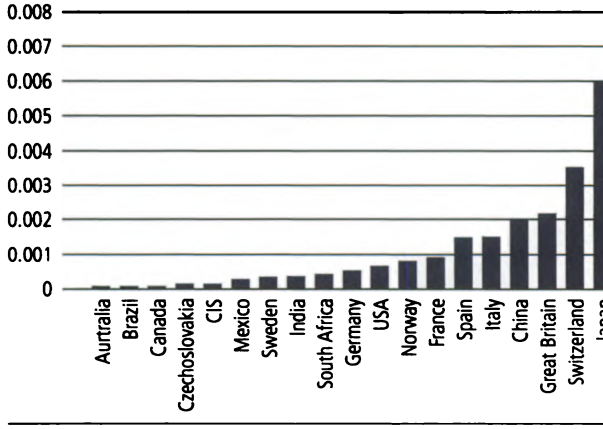
a) Numbers of large dams/km of river x 1000



b) Gross storage (Mm^3)/mean annual runoff (Mm^3)



c) Numbers of large dams per km^2 of land



Sources: include International Commission on Large Dams; US Commission on Large Dams (USCOLD); and Dynesius and Nilsson, 1994

3.3.3 Urbanisation

Cities place pressure on freshwater ecosystems because the sustenance of the high concentration of people in one place requires large inputs of natural resources and tends to overload the sink capacity (e.g. for pollutants) of natural systems in the vicinity of a city. For example, Mexico City (population over 10 million) consumes 1 km^3 y^{-1} more water than can be provided by renewable sources in its abstraction area (DVL/OS, 1997), and Sana'a, Yemen (population over 1 million), is mining fossil aquifers to provided water for its population. In Zimbabwe, failure to properly treat the wastewater generated by the people and industry of Harare is placing the water quality of reservoirs and rivers in the vicinity of the city at risk (see Box 8). It is estimated that at least 600 million urban dwellers in Africa, Asia and Latin America live in housing that is so overcrowded and of such poor quality, with such inadequate provision of water, sanitation and drainage, that their lives and health are continually at risk (United Nations Centre for Human Settlements, 1996).

Box 8

Pollution of Harare's water

A recent government survey of Harare's water supply detected faecal contamination at some sampling points. The Harare City Council's (HCC) practice of dumping untreated wastewater in Lake Chivero, Harare's main water source, has led to high levels of organic matter that favour the formation of carcinogenic micro-pollutants, like chlorinated hydrocarbons. These are difficult to remove and the local laboratories have only a limited capacity to monitor them. The HCC will have had to spend nearly ZWD 200 million (US$ 5 million) in 1999 to treat Harare's drinking water, twice the amount spent in 1998. Earlier in 1999, the HCC escaped prosecution by the Ministry of Water Development, on a technicality, for continuing to pollute the capital's water sources. In 1997, the University of Zimbabwe found levels of mercury in Harare's tap water to be up to 10 times higher than World Health Organisation (WHO) guideline values.

Source: The Zimbabwe Standard, 1999

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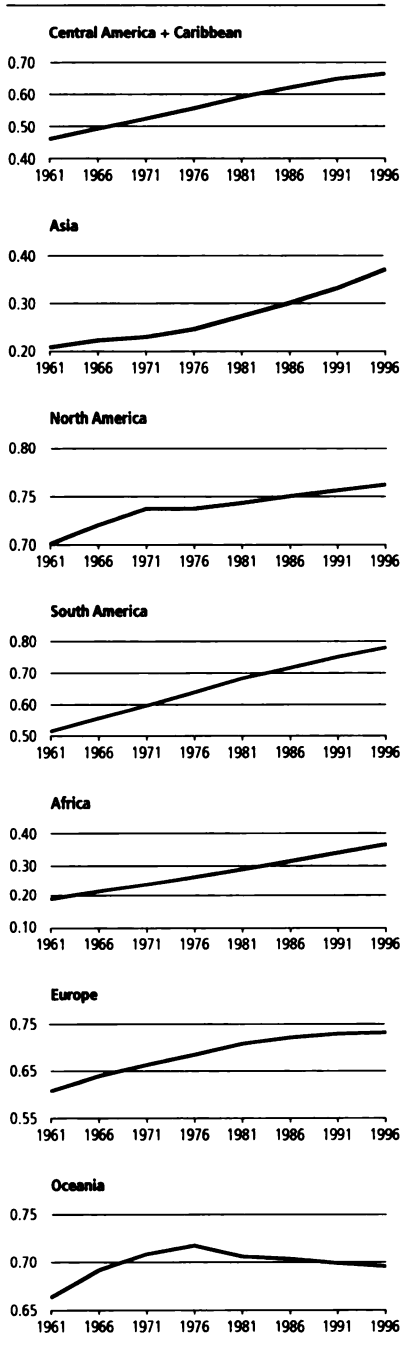
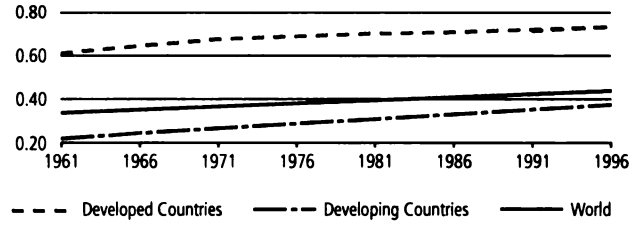
Figure 11a Change in the proportion of urban population by continent (1961-1996)



Source: FAO, Waicent database

Figure 11b Change in the proportion of urban population in developed and developing countries (1961-1996)



Source: FAO, Waicent database

The index used to illustrate the changing pressure of urbanisation on ecosystems is simply the proportion of population living in cities (see Figure 11). Once again, it is a relatively crude indicator since it does not indicate the extent of investment in infrastructure (e.g. wastewater treatment plants) to protect the environment from the impact of higher urban population. Over the 35 years from 1961 to 1996, the worldwide proportion of the population living in the urban environment increased from 0.34 to 0.46. In 1995, 321 cities had populations in excess of 1 million, and there were 15 mega-cities with populations of 10-20 million. The proportion of the population in cities is 0.73 and 0.38, in developed and developing countries, respectively. However, the highest rates of urban growth are in developing countries (i.e. in Africa, South America and Asia), which are those least able, through lack of resources, to ameliorate the impact on the environment of greater urbanisation. It is estimated that by 2025, 56% of the population will be urban and there will be more than 30 mega-cities (WMO, 1997). The increase in the world's urban population has consequences for water planning and management around the globe.

3.3.4 Freshwater fisheries

The size of the annual freshwater fish catch provides a crude indicator of human exploitation of the natural resource function provided by freshwater ecosystems. Fish constitute a major source of animal protein throughout the world, especially in many tropical and subtropical countries. The change in freshwater fish catches between 1961 and 1996 is presented in Figure 12. This has been calculated from the Food and Agriculture Organisation's (FAO) statistics and is simply the total fish catch minus the marine fish catch.

The data show that between 1961 and 1996 there was a five-fold increase (from 8.7 $x10^6$ to 45.6 $x10^6$ metric tons, or MTs) in the worldwide freshwater fish catch. The greatest growth has been in developing countries, particularly those in Asia, where over the same period there was nearly an 8-fold increase. Even allowing for the increase in farmed fish (estimated to have averaged 11.2 x 10^6 tons per annum between 1993 and 1995 (WRI et al., 1998)), this still represents a very significant increase in the human exploitation of the natural fish resource. Although the case for overexploitation of the fishstock is not as clear as for marine fish, nevertheless it is considered that most freshwater fishes are being exploited at, or above, sustainable levels (Abramovitz, 1996).

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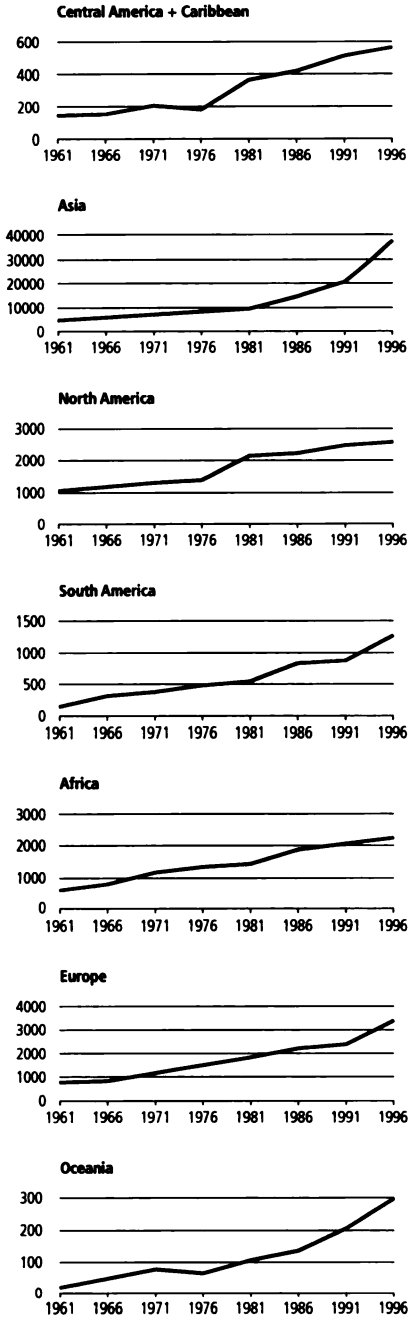
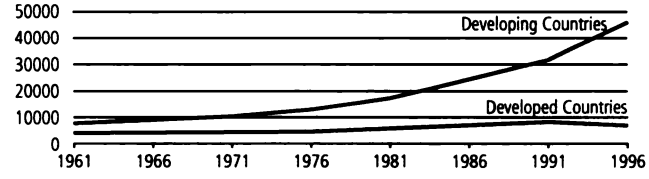
Figure 12a Change in freshwater fish catch (MT x 1000) by continent (1961-1996)



Source: FAO, Waicent database

Figure 12b Change in freshwater fish catch (MT x 1000) in developed and developing countries (1961-1996)



Source: FAO, Waicent database

3.3.5 Climate change

The Intergovernmental Panel on Climate Change (IPCC) concludes that since the late 19th century, human-induced emissions of gases such as carbon dioxide (CO_2) that trap heat in the atmosphere have contributed to an increase in global mean surface air temperatures of 0.3 to 0.6°C. Moreover, based on the IPCC's mid-range scenario of future gas emissions and aerosols and their best estimate of climate sensitivity, a further increase of 2°C is expected by the year 2100.

There is little doubt that climate change will alter the globe's hydrological cycle in a variety of ways, but there is at present little certainty about the form these changes will take. At the most general level, IPCC (1996) predicts that:

> *Warmer temperatures will lead to a more vigorous hydrological cycle; this translates into prospects for more severe droughts and/or floods in some places and less severe droughts and/or floods in other places. Several models indicate an increase in precipitation intensity, suggesting a possibility for more extreme rainfall events.*

However, many more impacts will occur. Changes in evapotranspiration, snowmelt, runoff and soil moisture will all affect freshwater ecosystem integrity, both directly and indirectly, as a result of human interventions designed to compensate for changes in water resources.

The hydrology of arid and semi-arid areas is particularly sensitive to climate variations. Relatively small changes in temperature and/or rainfall can have significant effects on evapotranspiration and groundwater recharge. These changes will affect both the total annual flow in rivers and its distribution through the year. In a dry area of Tanzania, model results indicate a dramatic 40% decrease in recharge caused by a 15% reduction in annual rainfall, which is further accentuated under degraded conditions to a 58% decrease (Sandström, 1998). Since dry season flow in rivers is maintained by groundwater recharge, this has severe implications for freshwater ecosystem integrity in this and similar areas.

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3.4 Indicators of the state of freshwater ecosystems

Human-induced pressures result in changes in freshwater ecosystems. In this section, a range of themes and indicators of the changing state of freshwater ecosystems are presented. As with the previous section, the themes are illustrative rather than a complete compilation and, once again, the indicators must be treated with caution because there are problems with data collection and analysis.

3.4.1 Loss of wetlands

Wetlands, as defined by the Ramsar convention, are:

areas of marsh, fen, peatland or water, whether natural, artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed 6 m.

This definition, although encompassing saline-water systems, also incorporates a widerange of different freshwater ecosystems. Consequently, although there is not a direct one-to-one correspondence between the terms, loss of integrity or destruction of wetlands is an indicator of pressures on freshwater ecosystems. Furthermore, it should be noted that the integrity of estuarine, deltaic and coastal wetlands is also dependent on inputs of fresh water (see Box 2). Loss of wetlands may arise either directly from conversion to agricultural, industrial or residential use, or indirectly as a consequence of human-induced change elsewhere in the catchment in which the wetland is situated.

The amount of wetland lost is difficult to quantify for three reasons. First, the total area of wetland in the world is uncertain and different countries delineate different wetland 'types.' Second, in many parts of the world the extent of wetland coverage in the past is unknown. Third, the definition of 'loss' is subject to a wide range of different interpretations. However, despite these limitations, figures for loss of wetland provide a crude indication of pressure on freshwater ecosystems.

Table 7 presents figures for wetland loss in a number of countries and an estimate of the global loss since 1900. These average national loss figures hide much greater variation within regions. For example, in the USA it is estimated that Iowa has lost 99% of its original marshes, Louisiana 50% of its forested wetlands and Wisconsin 32% of its wetlands (Tiner, 1984).

Table 7 Wetland loss

Country	Period	% loss of wetlands
Netherlands	1950-1985	55
France	1900-1993	67
Germany	1950-1985	57
Spain	1948-1990	60
Italy	1938-1994	66
Greece	1920-1991	63
USA	1970-1985	54
World	1900 to date	50

Various sources

3.4.2 Water pollution

All natural waters contain a variety of contaminants arising from erosion, leaching and weathering processes. To this natural contamination is added that arising from human sources (i.e. pollution). Any freshwater ecosystem is capable of assimilating a certain amount of pollution without serious effects because of the dilution and biological self-purification mechanisms that are present. However, if additional pollution occurs, the nature of the receiving water is altered and its suitability for various uses may be impaired (i.e. the system is degraded).

The type of water pollution that occurs is closely linked to water use and levels of socio-economic development (see Figure 13). The industrialised countries have experienced a series of freshwater pollution problems involving domestic, industrial and agricultural wastes. Legislation and technology have been used to control each wave of pollution as it has occurred. Today, pollution from industrial wastes is beginning to be curbed, but issues arising from non-point source pollutants (i.e. acidification, organic micro-pollutants, nitrates and groundwater contamination) are on the increase (see Figure 13). In the developing countries, the rapid growth of urban population, particularly in South America and Asia (see section 3.3.3), has outpaced the ability of governments to expand sewage and water infrastructure and domestic waste is a major problem. In some countries, this remains the principal pollution problem. However, in rapidly industrialising countries, all the problems faced by the developed countries are being experienced, but later and in more rapid succession than occurred in the developed countries (see Figure 13). Groundwater pollution as a consequence of urbanisation, of industrial activity, and from agriculture, is increasingly a problem worldwide.

One manifestation of freshwater pollution is eutrophication. Eutrophication of freshwater ecosystems involves the deregulation of ecological processes in water and soil due to excessive supply of nutrients in the form of phosphates and nitrogen compounds. Eutrophication is evidenced, for example, in undesirably large quantities of algae in ponds, lakes or rivers. As a result of eutrophication, plant species that thrive in low-nutrient environments are disappearing. In addition, the nitrate levels in groundwater are rising to such an extent that in a growing number of places the preparation of drinking water is under threat. In the United States, for example, nitrate contamination is the nation's most widespread groundwater pollution problem; in a national survey, 22% of wells in US agricultural areas contained nitrate levels in excess of the federal limit (US EPA, 1995). The main eutrophying agents are phosphates and nitrates derived primarily from a number of sources: fertiliser, manure, wastewater, sewage sludge, dredge spoil and solid waste.

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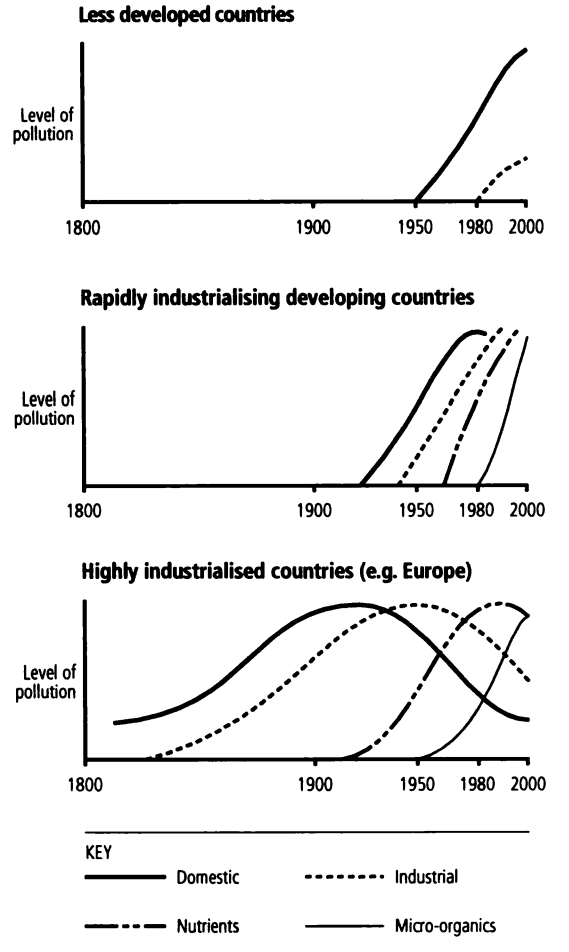
Figure 13 Conceptual evolution of the development of water pollution in relation to socio-economic development



Source: UNEP, 1991

Worldwide total fertiliser application increased from 31,182,240 metric tons (MT) to 134,324,000 MT between 1961 and 1991. Eutrophication pressure is worst in Europe where large amounts of fertiliser have been applied to a relatively small total land area. Although Europe is the one part of the globe where fertiliser application rates have decreased significantly in recent years (a drop of 31% between 1986 and 1991), the legacy of high fertiliser application is likely to remain for many decades to come. Asia has experienced the most rapid growth in possible eutrophication pressure as a consequence of fertiliser application; a 15-fold increase between 1961 and 1991. The gap in potential eutrophication between developed and developing countries has decreased significantly in recent years.

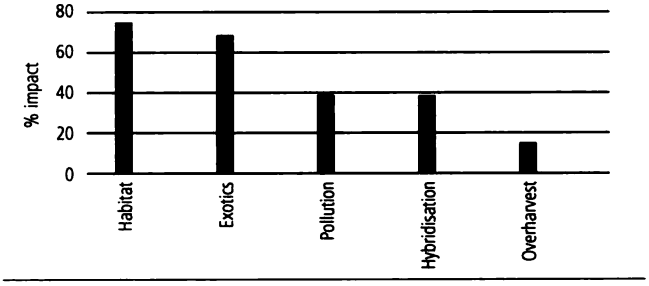
3.4.3 Freshwater biodiversity status and trends

The proportion of the world's surface unaffected by humans is now very small. Pollution and human-induced climate change are affecting all parts of the planet. However, there remains a large proportion of the globe that can still be considered 'natural habitat' (i.e. has not experienced a form of land-use change). It is estimated that 'natural habitat' comprised about 70% of the total land surface in 1990, but it is forecast that this will decrease to 60% by 2025 (DVL/OS, 1997).

Freshwater habitats are very rich in certain organisms; freshwater fish comprise 40% of all fishes and freshwater molluscs comprise 25% of all molluscs. As with many terrestrial and marine ecosystems, freshwater biodiversity tends to be greatest in tropical regions (see Table 8). The richest habitats for freshwater biodiversity include foothill streams, lowland rapids, as well as some peat swamps and ancient lakes.

The loss of freshwater biodiversity is poorly monitored except for some larger, commercial species. Available data suggest that between 20 and 35% of freshwater fish (the total number of species worldwide is estimated to be anywhere between 9,000 and 25,000) are vulnerable or endangered, mostly because of habitat alteration (see Figure 14). Of seven species of freshwater dolphins, one is vulnerable, two are endangered and one is critically endangered. Of 23 species of crocodile, 10 are threatened. According to IUCN (1996), many of the world's 4,522 known species of amphibians are threatened.

Figure 14 Causes of degree of impact on extinction of North American freshwater fishes. More than one factor may contribute to an extinction.



Source: McAllister, 1998

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Figure 15a Threatened species of fish

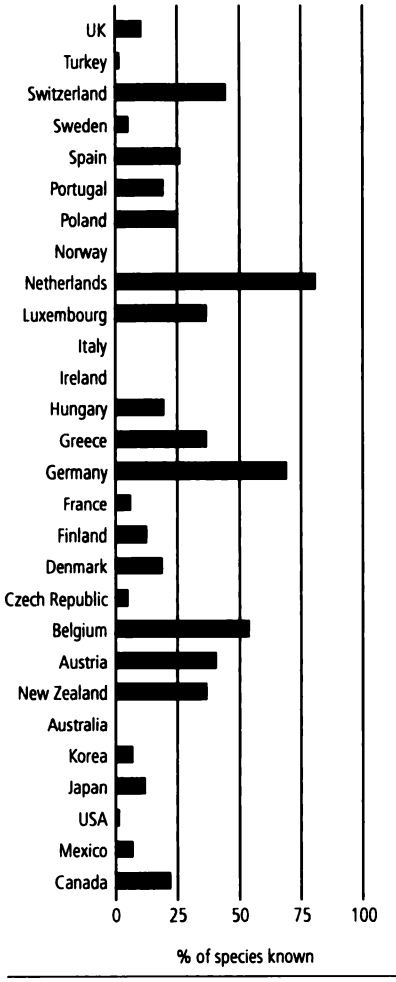
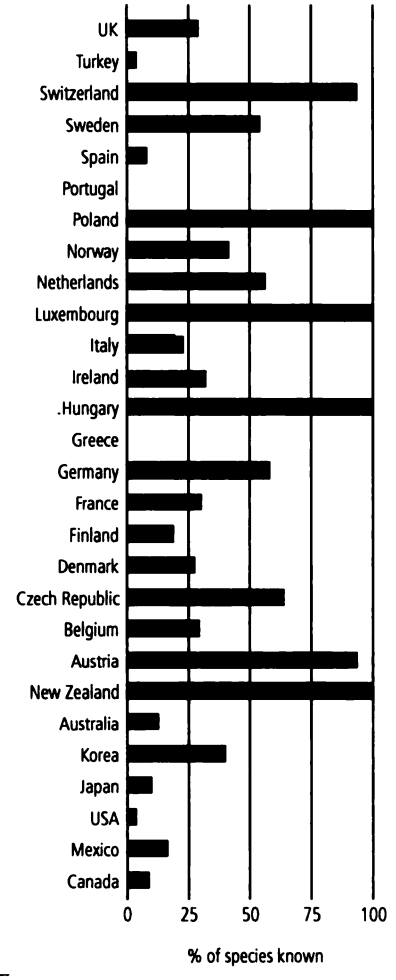


Figure 15b Threatened species of amphibians



Source: OECD, 1999

The proportion of threatened species of fish and amphibians for a number of OECD countries are presented in Figure 15. It is probable that the fish statistics include saltwater fish, although this is not made clear in the report from which these figures are taken (OECD, 1999).

3.5 Indicators of environmental security

It is a key tenet of this paper that pressures on freshwater ecosystems often translate to a reduction in environmental security. However, because of the spatial and temporal variation in the natural resource endowments provided by freshwater ecosystems, it is difficult to establish theoretical values linking pressures and changes in security directly. In this section, the themes and indicators presented mark different attempts to quantify key elements of human-environmental security associated with freshwater ecosystems.

3.5.1 Water scarcity

There are a large number of measures of water sufficiency. A commonly used index is the use-to-resource ratio, which is simply the ratio of water withdrawals to renewable water resources estimated at the country level (e.g. Raskin et al., 1995). It is difficult to establish a link between the use-to-resource ratio and the levels of water efficiency, but a country which withdraws a large fraction of its renewable resources is likely to encounter water scarcity. For example, in Egypt, the use-to-resource ratio is 0.97 and clearly reflects the water stress in that country. In the USA, the relatively low ratio of 0.19 suggests an overall water abundance, while masking water shortages in the arid western regions of the country. Table 9 presents use-to-resource ratios for those countries where it exceeds 0.25-the threshold often taken to indicate 'water stress.' It is important to emphasise that, in the analysis conducted to derive these ratios, 'water use' refers to withdrawals, not water consumption. In situations where withdrawals are heavily for non-consumptive uses (e.g. power plant cooling) the use-to-resource ratio may exaggerate the pressure on water resources.

In an attempt to incorporate spatial and temporal variation into the discussion of water scarcity, Meigh et al., (1998) have developed a number of indices and a computer model to determine 'water availability.' The indices attempt to incorporate variation in supply and demand, either within years or from year to year. The most complex index (IT4) is defined as the minimum over all months of:

$$I_{T4} = \frac{mr(90\%) + mgy - md}{mr(90\%) + mgy + md}$$

where: mr(90%) is 90% reliable monthly runoff
mgy is monthly groundwater yield
md is demand for that month

The index I_{T4} varies from –1 (negligible water available to meet demand) through zero (available water meets demand) to 1 (available water much greater than demand). The computer model makes allowance for return flows and so demands are consumption rather than just withdrawals. The model has been used to derive I_{T4} for cells in a 0.5 by 0.5 degree grid covering eastern and southern Africa. The grid size chosen is a compromise between that needed to represent spatial variation and the availability of the data required by the model.

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Table 8 Freshwater fish species: Number per country and species per unit land area

Country	Number of species	Number of species/ 1000 km²
Countries with most species		
Brazil	3,000	0.36
Indonesia	1,300	0.72
China	1,010	0.11
Zaire	962	0.42
Peru	855	0.67
United States	779	0.09
India	748	0.25
Thailand	690	1.35
Tanzania	682	0.77
Malaysia	600	1.83
Countries with most species per km²		
Burundi	209	8.15
Malawi	361	3.84
Bangladesh	260	2.00
Malaysia	600	1.83
Sierra Leone	117	1.63
Lao P.D.R.	350	1.48
Cambodia	260	1.47
Vietnam	450	1.38
Thailand	690	1.35
Uganda	247	1.24

Source: World Bank, 1998

Table 9 Current water constraints according to use-to-resource index

Country	Index *	Country	Index
Kuwait	Very high	Spain	0.41
Libya	3.74	Jordan	0.41
United Arab Emirates	3.00	Madagascar	0.41
Saudi Arabia	1.64	Iran	0.39
Yemen	1.36	Morocco	0.36
Egypt	0.97	Pakistan	0.33
Israel	0.86	Singapore	0.32
Belgium	0.72	Germany	0.31
Tunisia	0.53	Italy	0.30
Afghanistan	0.52	South Africa	0.29
Republic of Korea	0.44	Poland	0.26
Iraq	0.43		

Source: Raskin et al., 1995

* Note: use-to-resource index can exceed 1 when water use exceeds the renewable water supply. For example, in Kuwait, desalinated water is the primary source of fresh water for drinking and domestic purposes, and in Libya, the present rates of exploitation of groundwater exceed the rates of recharge.

It is important to note that in all analyses of water scarcity, the 'demand' considered is usually direct human demand for water for use in industry, irrigation and domestic consumption. However, there is no reason why demand cannot include environmental requirements for water if this can be defined.

3.5.2 Access to safe water and sanitation

In 1977, The United Nations Water conference declared that all people have the right of access to drinking water in quantities and quality equal to their basic needs. Two decades later, an estimated 1.1 billion people still do not have access to safe drinking water and 2.9 billion do not have access to adequate sanitation (UNICEF, 1996). In Cambodia, only 7 per cent of the population has access to safe drinking water. Improved water supply and sanitation services for those who lack them would do much to reduce the global burden of water-related diseases and so enhance environmental security.

Figure 16 shows how the proportion of the population that has access to safe drinking water and sanitation in developing countries changed between 1980 and 1994. It is important to note that the total number of people without access to safe drinking water fell from 1.8 to 1.1 billion; the total number of people without access to sanitation increased from 1.7 to 2.9 billion.

Limitations with the data include different definitions of 'access.' For example, in Africa, access to a pit latrine may be considered access to sanitation, but in many countries in South America, only access to a pipe sewage network is considered access to sanitation.

3.5.3 Water-related diseases

Interactions between human populations and freshwater ecosystems have consequences for health. The World Health Organisation (WHO) tentatively estimates that there are in the order of 250 million cases of water-related diseases and roughly 5 to 10 million deaths annually (see Table 10). Water-related diseases are of major concern in most of the developing world, but have been largely eliminated from industrialised countries.

Drinking water contaminated with human or animal excreta is the main source of water-related disease. These include most of the enteric and diarrhoeal diseases caused by bacteria, parasites and viruses, such as cholera, giardia and rotaviruses. In the developed world, dramatic improvements in public health were obtained in the 1800s as a consequence of protecting and treating drinking water supplies. Figure 17 indicates that deaths from cholera now occur predominantly in Asia and Africa.

Water-based diseases come from hosts that live in water or require water for their life cycle. The two most widespread examples are schistosomiasis, which results from contact with snails that serve as hosts, and dracunculiasis (guinea worm), which results from ingesting contaminated host zooplankton.

Schistosomiasis currently infects 200 million people in 70 countries. Worldwide prevalence of the disease has risen over the last five decades, due mostly to the expansion of irrigation systems in hot climates (WRI et al., 1998). The slow-moving water in irrigation channels, drainage ditches and at the edge of reservoirs provides ideal habitats for the host snails. Clear links to increases in schistosomiasis have been documented in irrigation projects such as the Mwea project in Kenya, where schistosomiasis accounts for 18% of all deaths (WRI et al., 1998). Following construction of the Diama dam on the Senegal River, the prevalence rate of schistosomiasis rose from 2% to 72% (Bergkamp et al., 1998). In Ghana, schistosomiasis prevalence tripled in the late 1950s and early 1960s when a large number of agricultural impoundments were constructed (WRI et al., 1998).

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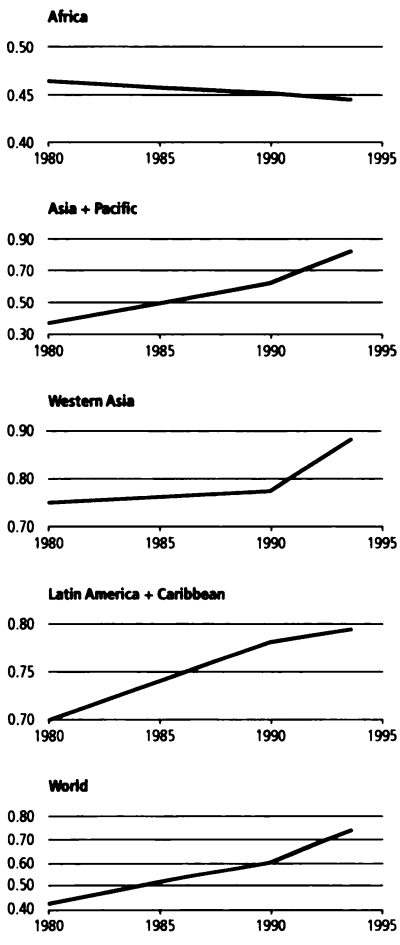
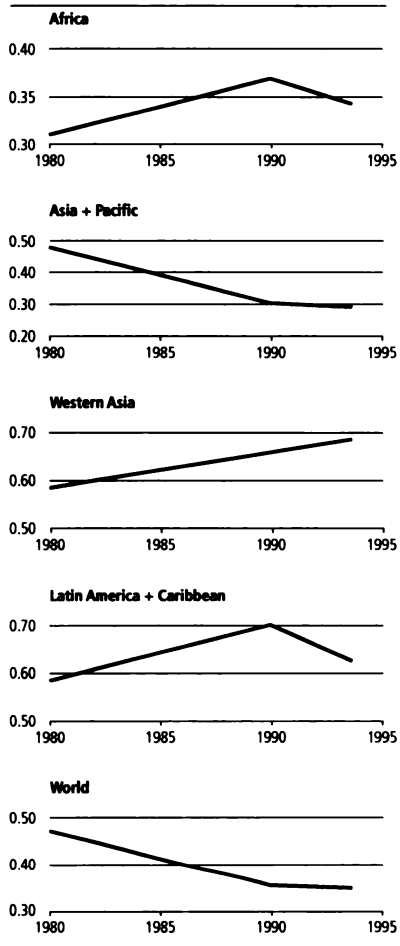
Figure 16a Access (i.e. proportion of the population served) to safe drinking water (1980-1994)



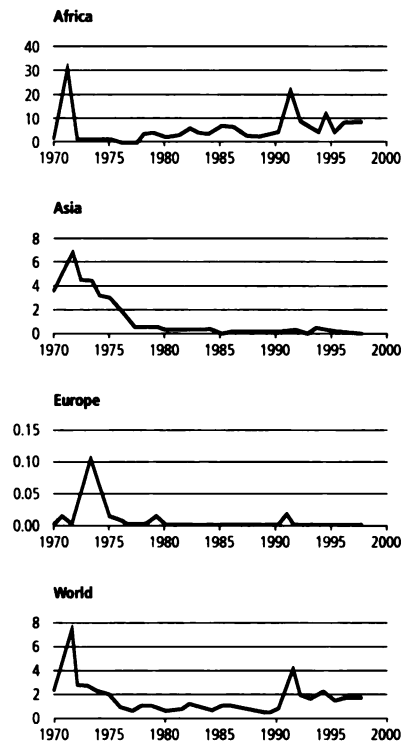
Source: Gleick, 1998

Figure 16b Access (i.e. proportion of the population served) to sanitation in developing countries (1980-1994)



Source: Gleick, 1998

Figure 17 Cholera index (nos. of deaths per million) as an indicator of environmental security



Source: Gleick, 1998

Over the last decade, the number of cases of dracunculiasis has dropped by 97% from an estimated 3.5 million cases in 1986 to about 150,000 cases worldwide in 1996 (Gleick, 1998), and it is hoped that the disease may be eradicated in about 5 years. The thrust of control strategies is to educate people about the origin of the disease and about the measures they and their communities can take to prevent it. It is relatively simple to filter water to remove the infected hosts, and household members can be taught to prevent worms from entering sources of drinking water.

Diseases associated with water-related insect vectors include malaria, onchocerciasis, trypanosomiasis, dengue fever and yellow fever. Modification of freshwater ecosystems that create or remove conditions favourable to their hosts may increase or reduce the prevalence of these diseases. For example, the draining of wetlands made a significant contribution to the eradication of malaria in many developed countries. However, in Africa, deforestation favours malaria transmission by a species of mosquito which prefers to breed in the open rather than in dense forest. In the Usambara mountains in north-east Tanzania, forest clearing activities along the mountaintops are considered one cause for the introduction and spread of malaria (WRI et al., 1998). At present, three to four hundred million people carry the malaria parasite and malaria accounts for 20 to 30% of childhood deaths in developing countries.

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It is impossible to quantify the additional toll of diseases related to irrigation, land conversion and other human-induced changes in freshwater ecosystems. The complex relationships between habitat modification, the functioning of ecosystems and the transmission of disease mean that it is difficult to predict how changes in freshwater ecosystems will affect disease rates, especially when the vulnerability of exposed populations varies so widely with income, access to health care and proper nutrition. Nevertheless, it is fair to say that, on balance, these changes contribute to the overall burden of water-related disease and so reduce environmental security.

3.5.4 Impact of floods

Another aspect of environmental security related to freshwater ecosystems is exposure to too much water (i.e. floods). Floods play a dual role with regard to human welfare. Sometimes they provide environmental security through the maintenance of floodplain services (see Box 3). However, in other circumstances they reduce environmental security, bringing death and destruction to communities. In this section, their destructive role is discussed.

Floods are the most frequent and damaging of all types of natural disaster. The negative impacts of floods for people are often exacerbated as a consequence of increased populations living on the floodplains. In some cases, this arises because of increasing population pressure and scarcity of land. However, in other instances, it results from social choice; people choose to settle and build on floodplains when, as a consequence of river engineering, they perceive the threat of floods has been removed. However, in many instances this perception is incorrect because, although river engineering often reduces frequent flooding, it rarely completely prevents flooding in major runoff events. In major floods (i.e. those with a long return period), dams spill and embankments, dykes and levees are overtopped, sometimes with disastrous effects for people living on the floodplain.

Few countries are spared the effects of floods and, between 1991 and 1995, it is estimated that floods caused more than US$ 200 billion in losses, almost half of all economic damage caused by disasters during the same time span. Each year floods are responsible for a quarter of deaths due to natural disasters and, in 1996 alone, 60 million people were affected by this natural hazard (Miller, 1997). In the worst natural disaster this century, 3.5 million people lost their lives as a consequence of flooding in Hwang-Ho in China.

Asia is the continent that suffers the most from floods (see Figure 18). It suffered 44% of all flood disasters and 93% of flood-caused deaths in the period 1987-1996. The high death toll is not only due to the dense population in the flood plains of the region, but also the difficulties that the developing countries in Asia face in mounting effective flood defences (Miller, 1997).

Table 10 Estimates of morbidity and mortality of water-related diseases

Disease	Morbidity (episodes/year or as stated)	Mortality (deaths/year)	Relationship of disease to water supply and sanitation
Diarrhoeal disease	1,000,000,000	3,300,000	Strongly related to unsanitary excreta disposal, poor personal and domestic hygiene, unsafe drinking water
Infection with intestinal helminths	1,500,000,000[1]	100,000	Strongly related to unsanitary excreta disposal, poor personal and domestic hygiene
Schistosomiasis	200,000,000[1]	200,000	Strongly related to unsanitary excreta disposal and absence of nearby sources of safe drinking water
Dracunculiasis	100,000[1,2]	–	Strongly related to unsafe drinking water
Trachoma	150,000,000[3]	–	Strongly related to lack of face washing, often due to absence of nearby sources of safe water
Malaria	400,000,000	1,500,000	Related to poor water management, water storage, operation of water points and drainage
Dengue Fever	1,750,000	20,000	Related to poor solid wastes management, water storage, operation of water points and drainage
Poliomyelitis	114,000	–	Related to unsanitary excreta disposal, poor personal and domestic hygiene, unsafe drinking water
Tryponosamiasis	275,000	130,000	Related to the absence of nearby sources of safe water
Bancroftian filariasis	72,800,000[1]	–	Related to poor water management, water storage, operation of water points and drainage
Onchocerciasis	17,700,000[1,4]	40,000[5]	Related to poor water management in large-scale projects

Source: Shiklomanov, 1997

[1] People currently infected
[2] Excluding Sudan
[3] Cases of the active disease. Approximately 5,900,000 cases of blindness or severe complications of Trachoma occur annually
[4] Includes an estimated 270,000 blind
[5] Mortality caused by blindness

Flood magnitude and frequency may be altered by human-induced changes in freshwater ecosystems. For example, deforestation in the middle and upper reaches of the Yangtze River and its tributaries is widely attributed to have exacerbated the recent floods in China (The Economist, 1998). Although the exact nature of catchment response to deforestation is very site-specific, removal of trees, particularly in the dry tropics, tends to result in reduced rates of infiltration and percolation and hence increased runoff (Sandström, 1998). Flooding is a natural phenomenon that will inevitably occur from time to time. It is impossible to ascertain a direct relationship between human modification of catchments and freshwater ecosystems and the consequent impact of floods. However, if societies continue to build houses and cities on floodplains, then the negative impact of floods will continue. This problem has been recognised in the USA and, following the floods on the Mississippi in 1993, substantial federal disaster funds have been used for the first time, for the voluntary relocation of residences and businesses located on the floodplain (Devine, 1995).

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3.6 Synthesis: Links between pressures, environmental state and security

Although far from comprehensive, the problems identified and discussed in this chapter are the currently most pressing issues in the context of freshwater ecosystems. Although there are problems with all the indices presented, they provide a crude way of assessing temporal and spatial variation in the human-induced pressures on freshwater ecosystems and the state of those ecosystems. As of yet, there is no method of integrating the indices to derive an index of either total pressure or current state. It is recognised that the synergistic effects of several different pressures will have a cumulative impact that is different to the simple sum of the individual pressures (Gosselink et al., 1990). Furthermore, because of the complex nature of interactions between humans and the environment, it is currently impossible to derive quantitative links between indices of pressure and ecosystem state, and environmental security. Statistics alone cannot adequately describe the pressures on freshwater ecosystems, their state nor environmental security. Recognising these limitations, the indices nevertheless provide useful information.

The indices show that, worldwide, there is a tendency for increasing human pressure on natural freshwater ecosystems. Conversion of land to agricultural use, deforestation, urbanisation, dam construction and freshwater fishing continues to impact freshwater ecosystems everywhere. In the future, it is likely that climate change will induce significant changes in the state of freshwater ecosystems. Many of the indices show that, to a large extent, the pressures are greatest in the developing countries which, not uncoincidentally, are where people currently have the lowest environmental security and populations are increasing most rapidly. In the developed world, some pressures are decreasing (e.g. the rate of conversion to agricultural land), but it is in the developed countries that natural freshwater ecosystems have already experienced the greatest alteration.

The indices show that worldwide natural freshwater ecosystems are becoming increasingly altered by human intervention. The loss of wetlands, water pollution and the changing status of biodiversity all indicate a decline in the 'naturalness' of freshwater ecosystems. The water pollution indices highlight how the problems faced by freshwater ecosystems change as countries become increasingly industrialised; while some pressures may be moderated, new pressures arise. Nevertheless, in the developed world, there has been an overall improvement in the state of some freshwater ecosystems in recent years, particularly with regard to water quality. To date, this has been achieved primarily through engineering solutions and heavy investment in end-of-pipe technologies.

Figure 18a Number of flood disasters 1987-1996 by continent

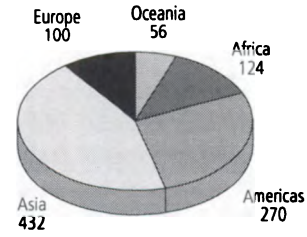


Figure 18b Flood damage 1987-1996 (in millions of dollars)

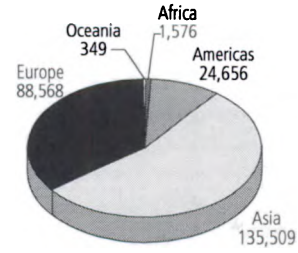
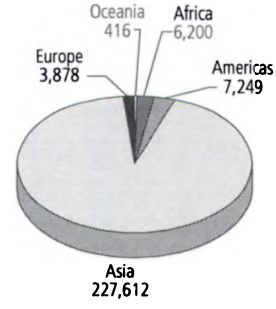


Figure 18c Deaths from floods 1987-1996 by continent



Source: Miller, 1997

Worldwide indicators of environmental security are mixed. At present, the greatest levels of human security are in the developed world (i.e. in those countries which have the most altered freshwater ecosystems). In these countries, water-related health risks have largely been overcome and, in general terms, societies are sufficiently prosperous to be able to choose between a range of options on how to manage freshwater ecosystems. In the developing world, for many people environmental security is greatly undermined by water scarcity, the continued lack of safe water and sanitation, and the consequent prevalence of water-related diseases.

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4. Scenarios: Assessment of long-range patterns and problems

Man (sic)... perfects, corrects and improves the works of lower nature. Therefore the power of man (sic) is similar to that of divine nature... How wonderful is the cultivation of soil all over the Earth, how marvellous the construction of buildings and cities, how skillful the control of waterways (Medieval humanist, Ficino, cited in Sale, 1992).

4.1 The scenario approach

The future state of freshwater ecosystems on this planet is dependent to a large extent on the way humankind opts to manage them. Decisions related to the management of freshwater ecosystems should not be implemented on the basis of trial and error, but require a thorough review of the prospective effects. The long-term consequences and the total outcome on both the environment and society must be determined. However, the complexity of the interplay between human activities and freshwater ecosystems means the future of these systems is inherently unpredictable. Three types of indeterminacy can be identified:

- insufficient information on present conditions, i.e. the state of systems and the forces governing their dynamics;
- even if precise information were available, complex systems are known to exhibit chaotic behaviour – extreme sensitivity to initial conditions and branching behaviours at various thresholds, which thwart prediction;
- human free will ensures that the future is unknowable.

While we cannot forecast the future accurately, we can use scenarios to present plausible futures; the scenarios are 'what if' propositions. Applied to long-range resource assessments, scenarios draw upon both science (i.e. our understanding of historical patterns, current conditions, and physical and social processes) and the imagination to conceive and evaluate a range of alternative pathways. In so doing, scenarios can illuminate the relationships within the total system, and the relationship between human actions and the whole complex of interconnected outcomes. It is this added insight, leading to more informed and rational decision-making, that is the primary objective of scenarios.

A water scenario has to include assumptions about many interacting elements: population and demographic patterns, lifestyles and consumption patterns, economic scale and structure, technology and efficiency, and policies and institutions. Three scenarios are presented. Although slightly modified, these are to a large extent based on those developed, in draft form, by the World Water Council's Scenario Development Panel. These scenarios, up to 2025, are:

Conventional water world: in which it is assumed that economic growth, technological advances and demographic trends continue as at present. Although a global water crisis is averted, there is increased stress on water resources, human health and ecosystems, and consequently a net reduction in environmental security, particularly in developing countries.

Water crisis: in which it is assumed that there is less dissemination of new technologies, slower economic growth and a failure to adopt water strategies. This results in increased water scarcity and a catastrophic reduction in environmental security in many regions.

Sustainable water world: in which it is assumed that water-related objectives and targets are given higher priority than at present and are widely adopted. This results in increased environmental security worldwide.

In this paper, the key elements of the scenarios are presented, with some additional information taken from other sources. The emphasis is on the technical issues relating to each scenario.

4.2 Conventional water world

The principal aspects of this scenario can be summarised as follows:

- Resource-intensive consumption patterns of developed countries continue unchecked;
- Worldwide population levels continue to rise, particularly in developing countries;
- Continued economic and social inequity between countries of the developed and developing world;
- Developing countries continue to try and switch from agrarian to industrial society;
- Populations are increasingly urbanised;
- Progressive globalisation of culture and commerce;
- Gradual convergence of developing and industrial economies;
- Climate change.

4.2.1 Consequences for freshwater ecosystems and environmental security

Changes in landuse increasingly affect water resources, particularly as a result of deforestation in moist tropical areas and grazing that has increased in arid areas. In developed countries, problems with toxic (micro-organic) pollutants and new strains of water-borne viruses in surface and groundwater become increasingly problematic. In the developing countries, problems of access to safe drinking water and adequate sanitation continue to pose the most significant risk to environmental security.

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The integrity and resilience of freshwater ecosystems continues to be degraded as a consequence of encroaching human settlement and pollution. Nonetheless, water-related diseases are kept at the same percentage levels that exist at present through some improved sanitation and water management. The death toll of curable water-related diseases such as diarrhoea, particularly among children, remains high. There have been no major widespread and dramatic epidemics of cholera or typhoid, but the chronic impact of low water quality remains a major health problem in developing countries.

The conversion of wetlands into arable land and residential areas has slowed, but not halted, except in some developed countries where the public outcry over the last remaining wetlands has led to costly actions to protect and even recreate small areas. In developing countries, water-based tourism remains economically important in some areas, but others have overexploited their resources and seen their tourism revenues decline.

There has been an increase of water use by agriculture because of an expansion of irrigated land. It is estimated that 60 per cent of all food will be produced by irrigation in 2025 (Lanz, 1995). Water-use efficiency has increased because of increased application of more efficient irrigation systems as well as the development of less-water-demanding crops. However, these gains only partly offset the increases in water withdrawals for irrigated lands. A slight shift from irrigated to rain-fed agriculture has occurred because the increase in yield of rain-fed agriculture grows faster than that of irrigated crops. This reduces the rate of water use for agriculture because irrigated lands, while accounting for an important fraction of agricultural production, represent a relatively small amount of total agricultural land in terms of area.

By 2025, worldwide water withdrawals reach 5,187 $km^3 y^{-1}$ and, of this, 2,879 $km^3 y^{-1}$ are consumed. Groundwater levels in many renewable aquifers gradually fall because withdrawal exceeds recharge. In many river basins, increased abstractions reduce the water reaching coastal deltas and this reduces fisheries that depend on inputs of freshwater and associated nutrients. Increased technological efficiencies and improved management prevent dramatic water crises. However, continued water degradation and increased costs of new water supplies make the global situation less resilient and more vulnerable to crises.

Humankind takes for direct use an even greater share of the limited renewable fresh water than today. This water can only be obtained at an increasing financial and ecological price. This results in increased stress on water resources, human health and ecosystems. The problems impacting on freshwater ecosystems are the same as today, but increased in number and consequences at the global scale. Biodiversity continues to decline rapidly. There are continued socio-economic problems due to persistence of poverty, failure to achieve global equity and increase in conflict over scarce water resources. Thus there is a net reduction in environmental security, particularly in developing countries.

4.3 Water crisis

Until 2015, this scenario follows a similar pattern to that of the conventional scenario (see section 4.2) except that overall global economic growth is slower and capital flows away from some parts of the developing world. After 2015, this results in a significantly worse water situation. The principal aspects of the scenario are as follows:

- Income inequality between the rich and poor countries increases and both relative and absolute levels of poverty rise;
- Economic globalisation has expanded the economy but various types of trade conflicts have reduced the overall rate of growth;
- Global cooperation is undermined by the scarcity of water;
- Many technological developments are applied in some parts of the world, but not others, thereby increasing inequities;
- Global food production and trading systems are becoming vulnerable to disruption;
- International and national equity have decreased significantly with related social tension and pressures for migration;
- Water withdrawals have continued to grow without the efficiencies expected from improved water resources management, resulting in acute water stress in many countries;
- Little progress has been made to solving current critical water problems, other than locally at a small scale;
- The resilience of natural and social systems is eroded to such an extent that climate change causes large-scale ecological collapse.

4.3.1 Consequences for freshwater ecosystems and environmental security

Despite their diversity, the events unfolding in this scenario have one thing in common; they all contribute to the general erosion of resilience in both human societies and the natural and ecological realms. The result is environmental degradation leading to critical resource scarcity and human catastrophes that in turn effect global economic processes, creating a downward spiral of reducing global security.

Water scarcity, combined with the need for irrigation and economic development, particularly in Africa, India and China, resulted in exceeding of the ecological thresholds required to protect ecosystems. This generates widespread degradation of freshwater ecosystems. With ecological resilience lost in those areas, some of the effects have global implications. Episodes of large-scale ecological collapse occur frequently, involving conversion of forests to agricultural land to dust-bowls or wastelands, eutrophication of inland freshwater bodies, collapses of freshwater fisheries, and increased catastrophic floods triggered by loss of ecological regulation at the catchment level. Biodiversity decreases at an ever-increasing rate.

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Water resource systems do not collapse globally, but major catchments and socio-economic regions are affected. International conflicts over shared water resources occur with increasing frequency. Water-use efficiency decreases as investment and maintenance decline. The price of water increases. Increasingly developed countries and corporate alliances look towards water-surplus areas such as the Congo and Amazon basins to grow their food and spare their water reserves for industrial and domestic use. However, this has devastating consequences for the ecosystems of these areas. Environmental security is severely compromised, worldwide.

4.4 Sustainable water world

The principal aspects of this scenario can be summarised as follows:

- The rate of growth in the human population is decreasing and it is forecast that it will stabilise (e.g. at 10 billion) by 2070;
- An international consensus is achieved on the principles that should govern utilisation of natural resources;
- Methods of resource evaluation have been developed and introduced – water is correctly valued and benefits provided by ecosystems understood as a consequence of research;
- Basic human needs for water have been identified. Significant advances have been made in providing access to water for drinking, sanitation and food preparation throughout the developing world;
- Domestic water use in the developed world is more efficient and equitable as a consequence of technological advances and reuse of wastewater for non-potable uses;
- Solar desalination is widespread;
- National and international actions to protect ecosystems have been established. These include comprehensive minimum environmental water commitments and international agreements on species protection and management. All international aid and development projects include explicit ecosystem protection and management components. Basic ecosystem water needs are identified;
- Water-related conflicts are resolved through negotiations. Formal agreements/treaties are signed for all the world's major river systems, including shared responsibility for environmental and ecological protection;
- Increased irrigation efficiency is obtained through adoption of modern technology (e.g. sprinklers, drip irrigation, sensor and computer technology);
- Climate change cannot be prevented, but management policies are flexible and adaptable enough to cope with changes that are occurring.

4.4.1 Consequences for freshwater ecosystems and environmental security

As a consequence of social, economic and technological changes, water withdrawals are stabilised at a sustainable level. Technological innovation increasingly concentrates on biosystems, harnessing the potential of ecosystems to produce resources necessary for life at low energy intensity and high material efficiency. The rate at which biodiversity is lost is considerably reduced.

Ecosystem restoration and rehabilitation becomes a leading sector of the economy. As a result, environmental quality improves. While not all ecosystems can be recuperated, many new, sustainable and productive ecosystems evolve. Freshwater ecosystems are managed in a sustainable manner and to the benefit of humankind as well as other flora and fauna. Environmental security is significantly increased.

4.5 Synthesis: Future water security

The foundation of the three scenarios described is the Conventional Water World, which has as its basis current trends and practices. The driving forces of the Conventional Water World then diverge at some point to produce either the Water Crisis or the Sustainable Water World.

Human intervention affects the state of freshwater ecosystems, and the services provided to human society, through the feedback mechanisms illustrated in Figure 7. Over the long term, these may be either negative (i.e. increased degradation of ecosystems so that there is a net reduction in benefits) or positive (i.e. reduced degradation and a net increase in benefits), depending on the nature of the intervention.

As discussed in section 3.2, the underlying reasons why the Conventional Water World results in a net decrease in environmental security, are primarily a consequence of: i) socio-economic insecurity outweighing the need to maintain environmental security; ii) ill-informed decision-making and iii) an inappropriate emphasis on technological solutions. If a Sustainable Water World is to be achieved, significant changes must be made in the way that humankind manages and utilises freshwater ecosystems. Many people argue that if drastic decreases in environmental security are to be avoided, changes must be implemented soon (e.g. Falkenmark and Lundqvist, 1998).

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The interaction of humankind with freshwater ecosystems is complex. Successful management must incorporate all social, economic and environmental elements in an integrated approach aimed at attaining specific goals. These goals should be targeted at increasing environmental security by building resilience in both social and environmental systems so that future change (e.g. arising from climate change) does not have detrimental impacts on either ecological integrity or human security. Consequently, management strategies must be holistic in nature and adaptable. It is important to note that requirements for improving environmental security vary from place to place; there are no simple recipe-book solutions.

To a large extent, social and economic interventions influence the global driving forces to a much greater extent than technical interventions. Nevertheless, at the catchment scale, technical intervention in conjunction with appropriate social and economic strategies can significantly alter the impact of human interventions on ecosystem integrity and hence environmental security. It is beyond the scope of this paper to describe the social and economic interventions in detail, but these are discussed in the other two papers in this series (Swanson and Doble, 1999; Soussan et al., 1999). In the following section, technical approaches and technological options that may be incorporated in the future management of freshwater ecosystems, and that will assist in approaching a sustainable water world, are discussed.

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5. Future Strategies

The need for integrated, basin-wide, water resource management is considered a prime security objective for the prospects of... regional cooperation (SIDA, 1995).

Freshwater ecosystems are changed as a consequence of land conversion, agriculture, pollution, major engineering schemes and urban development. As discussed above, these changes may alter ecosystems to the extent that benefits accrued by society from the natural functions and attributes of an ecosystem are lost. As such, human-induced changes can represent threats to environmental security. In this context, a degraded ecosystem is one which has lost some or all of its direct or indirect value to human society

Although there remains much debate about the best approach to reduce the impact of human intervention on freshwater ecosystems, there is growing recognition, at the highest political level, that wide-ranging and integrated strategies are required to resolve complex problems (see section 1). In this section, the role of ecosystem management as a conceptual framework on which to base future management of freshwater ecosystems is discussed. We argue that, although it provides a useful water 'ethic' ecosystem management is poorly defined and so does not provide a rational basis for environmental and natural resource policies. The concept of integrated catchment management (ICM) is conceived as a practical framework for implementing ecosystem management because catchments provide the most appropriate physical context in which to apply resource planning.

Mitigation and adaptation strategies are conceived as components of ICM that seek to alleviate the negative impacts of human intervention in freshwater ecosystems on environmental security. For the purpose of this paper these strategies are defined as follows:

- Mitigation strategies are strategies that are intended to significantly reduce or eliminate defined threats or sources of degradation. In terms of the conceptual model described in section 3.1, approaches which successfully mitigate human-induced change in freshwater ecosystems are those which break the link between the driving forces and the resulting pressure on the ecosystem. This can be achieved either by dealing with the driving force directly (e.g. reduction in population growth by stricter birth control) or by altering the anthropogenic response to the driving force (e.g. reduction in per capita water consumption through demand management).
- Adaptation strategies are strategies that seek to regain ecological services that have been lost as a consequence of human-induced change in an ecosystem. In terms of the conceptual model of environmental security described in section 3.2, strategies which alleviate the impacts of changes to freshwater ecosystems are conceptualised as those which break the link between pressures on the ecosystem and its state or, alternatively, break the link between the state of the ecosystem and the consequent impact on environmental security. In terms of Figure 6, this can be visualised as moving back towards the benefit peak from a position on the recession limb of the total benefits curve.

Within this paper, the emphasis is on technical aspects of mitigation and adaptation within the context of ICM. Although social-economic interventions are mentioned, these are dealt with in more detail in the other two papers of this series (Swanson and Doble, 1999; Soussan et al., 1999). It is important to recognise that the separation between mitigation and adaptation is somewhat arbitrary because, within the context of ICM, many technical interventions can be classified as either, or indeed both, depending on the specific circumstances in which they are applied.

5.1 Concepts

5.1.1 Ecosystem management

Ecosystem management is proposed by advocates as the modern and preferred way of managing natural systems. It is offered as a management approach that will protect the environment, maintain ecosystem functions, preserve biodiversity and ensure sustainable development (e.g. Norton, 1992). The basic idea is that resource and landscape management is tailored to landscape conditions, processes and potential so that desired features and processes of ecosystems are maintained and human needs are met in an optimal and sustainable way (Pirot and Meynell, 1998). This involves defining, on the basis of sound scientific evidence, the intrinsic capabilities and limitations of ecosystems to support, over the long term, a particular suite of human activities.

Others (e.g. Fitzsimmons, 1996) see the concept of ecosystem management as flawed because, despite the widespread acceptance of the general ideals, the concept remains full of ambiguity and, at present, there is no operational framework for integrating technical analysis into land use and natural resource decision-making. However, although these criticisms are valid, it remains the case that something like ecosystem management is needed to address the environmental and

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Table 11 Core principles in the management of ecosystems

Core principles underpinning ecosystem management	In the context of freshwater ecosystem management
Ecosystem management reflects a stage in the continuing evolution of social values and priorities; it is neither a beginning nor an end	Ecosystem management requires the definition of a goal and the design of a strategy to implement a mix of decisions to reach the goal. However, since society's values and priorities constantly change in ways that are not foreseeable, it is essential to develop strategies that are flexible and adaptable.
Ecosystem management is place-based and the boundaries of the place must be clearly and formally defined	Catchments are the most appropriate geomorphologic units on which to base management decisions related to fresh water. They can provide an analytical framework for gathering and interpreting environmental information at appropriate scales. However, it must be remembered that decisions to maximise the benefits in managing a 1000 ha catchment nested within a much larger watershed may well be very different than decisions for the same smaller catchment that were designed to maximise benefits over the entire catchment. Protection of ecosystem services downstream may involve constraints on upstream water-use and land-management.
Ecosystem management should maintain ecosystems in the appropriate condition to achieve desired social benefits	There is no baseline state against which to determine the 'condition' of natural freshwater ecosystems. The debate is really over determining 'desired' state; something that must be defined by society, not scientists alone.
Ecosystem management should take advantage of the ability of ecosystems to respond to a variety of stressors, natural and human-made, but all ecosystems have a limited ability to accommodate stressors and maintain a desired state	The key to successful freshwater ecosystem management is to balance ecosystem robustness (i.e. the ability to respond to stress) against human-induced alterations to the ecosystem so that the ecosystem is not altered beyond its ability to provide those benefits.
Ecosystem management may or may not result in emphasis on biological diversity	Like any other attribute of freshwater ecosystems, the value of biological diversity to society must be based on society's preferences. In many instances ecosystem functions can be maintained with reduced numbers of species. Hence, as a characteristic of ecosystems, biological diversity may operate as an ecological constraint on utilisation, not as a benefit, in the short-term, but may be a societal preference in the long-term.
The term sustainability, if used at all in ecosystem management, should be clearly defined – specifically, the time frame of concern, the benefits and costs of concern, and the relative priority of the benefits and costs	In management of freshwater ecosystems, the following questions must be answered: – what is to be sustained (e.g. water, functions, attributes)? – over what time frame is sustainability to be measured? – what is the scale of sustainability (e.g. a small catchment, a region or a country)?
Scientific information is important for effective ecosystem management, but is only one element in a decision-making process that is fundamentally one of public and private choice	Scientific understanding is essential for ecosystem management. However, such information often makes decision-making harder rather than easier. In deciding on how best to utilise ecosystems, it is necessary to appraise social and economic concerns within an overall context of seeking to increase total human security.

Adapted from: Lackey, 1998

social problems arising from the exploitation-focused, single-resource approach to management that has generally been applied in the past. There is a critical need to decide the role of science in policy-making and resource management.

It is beyond the scope of this document to analyse in detail the many issues raised by the concept of ecosystem management and discussed interminably in recent scientific literature. However, Table 11 summarises seven key principles of ecosystem management and comments on each in relation to the management of freshwater ecosystems. Here, we simply note the following:

- It is self-evident that water-dependent ecosystems rely on water for their existence and functions, and so provision of water is needed for their services to the environment and people.
- Land and water resources are linked, so it is essential that they are managed in an integrated manner.
- Although there are limitations, catchments nevertheless provide the most obvious physical entity on which to base management of natural resources, particularly freshwater (see section 5.1.2).
- Heavily-modified ecosystems can be sustainable over the longterm, in that the transformed systems can continue to be productive indefinitely, providing that appropriate management systems are established.
- Ecosystem management should seek to maximise the benefits to human society to be obtained from both the natural and non-natural services provided by any particular ecosystem (see Figure 6).
- To be successful, management practices must be based on knowledge of ecosystems and an understanding of social mechanisms. There is a need to develop methods that link the two directly.
- Local and traditional knowledge can be of immense value as a basis for designing and implementing management plans.
- Management should promote resilience within freshwater ecosystems on a longterm basis, and should be adaptable so that future changes in societal preference can be accommodated (Berkes et al., 1998). This has to be achieved by adoption of a variety of physical, social and economic policies and techniques, all aimed at minimising the adverse consequences of development. Scientists can assist by providing decision-makers with information on the resilience of freshwater ecosystems to alteration, and hence the possibility of maintaining options for future generations.
- Water allocation needs to be based on participation and joint decisions of all stakeholders.
- At present, the developed world's preference is seemingly paradoxical: wanting the benefits and affluence obtained through extreme modification of ecosystems but at the same time placing high value on the non-consumptive elements of ecosystems such as being pristine.

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5.1.2 Integrated catchment management

The concept of Integrated Catchment Management (ICM) recognises that successful natural resource management requires a holistic approach that integrates both land and wateruse, as well as technical and non-technical human interventions. The key tenet of the approach is that water catchments represent the most appropriate physical entity on which to base water management policy. The term is often used interchangeably with similar terms, including integrated water resources management, integrated watershed management and total catchment management. It can be defined as:

the coordinated planning and management of the water resources of a river basin considering its interaction with land and other environmental resources for their equitable, efficient and sustainable use at a range of scales from local to catchment level (DFID, 1997).

It is acknowledged that in some circumstances the surface water catchment (or watershed) is not the best-suited management unit. For example, when considering interventions that may affect groundwater, it is important to realise that groundwater catchments may be very different to surface water catchments. Furthermore, consideration must be given to the coastal region (strictly outside the catchment) affected by river flows. It is sometimes argued that the management unit considered should be modified to suit that which is most appropriate to the problem under consideration (i.e. the 'problemshed'). However, because the impact of interventions must be judged in relation to a particular area, it is essential to be able to delineate the boundaries of the area being considered. In many circumstances this is not easy (e.g. groundwater catchment boundaries are often very difficult to define). Thus, it is for pragmatic reasons that the surface water catchment has been proposed by many (e.g. Montgomery et al., 1995) as the most appropriate natural resource management unit.

ICM programmes comprise an overall strategy that clearly defines the management objectives, a range of delivery mechanisms that enable these objectives to be achieved, and a monitoring schedule that evaluates the programme performance. Mechanisms and policies are established that enable long-term support to programmes of environmental recovery (see Box 9).

Box 9

The Murray Darling Basin Initiative: The world's largest catchment management programme

The Murray Darling catchment covers more than one million square kilometres, one-sixth of Australia – and includes 24 major rivers. Salinity is a natural feature of the catchment. The problem is that changes in land use and water use have intensified this aspect of the catchment, resulting in conflict with human and environmental needs. Removal of natural vegetation has altered the water balance of the land so that water tables have been rising, leading over time to salinisation of the soil. Saline inflows, in turn, impact river water quality, with salinity endangering important aquatic and riparian ecosystems as well as threatening domestic water supplies for the city of Adelaide and much of South Australia.

In recognition of this and other problems in the catchment, the Murray Darling Basin (MDB) Initiative was established in 1987. The Natural Resources Management Strategy that deals with the management of the riverine environment, management of irrigated and dryland regions, and basin-wide issues, underpins the MDB Initiative. The riverine environment sub-programme covers three broad areas: improvements to water quality; river flows with respect to balancing human and environmental needs, and nature conservation. A salinity and drainage strategy has been developed for irrigated regions. Through this strategy:

- Improved land management techniques are being introduced to minimise the amount of irrigation water being added to the water table. Through the use of new crops and more efficient irrigation technology, this will encourage the use of land within its sustainable capacity.
- Engineering works are being constructed to intercept highly saline groundwater and pump it to suitable disposal sites before it flows into the main river system.
- New operating rules have been introduced to reduce evaporation losses from reservoirs.

In addition, the MDB Initiative recognises the role of wetlands in enhancing river water quality and the Floodplain Wetland Management Strategy has been developed. This aims to maintain and where possible enhance the floodplain wetland ecosystems. Constructed wetlands are being specifically designed to reduce nutrient loads from farm runoff, sewage treatment and industrial plants and urban runoff.

Throughout Australia, ICM and the Landcare system have encouraged farmers and other rural industries to work together with government and rural communities to solve a wide range of rural problems. The Landcare system combines elements of community and environmental education, action research and participatory planning. More than 2,000 voluntary Landcare community groups are currently working to develop more sustainable systems of land and water use supported by a national ten-year funding programme.

Source: Water Quality International, 1999

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The objective of ICM can be summarised as increasing environmental security through the following:

- In the short term, prevent further environmental degradation and, in the longer term, restore degraded resources;
- Promote sustainable agricultural, forestry, fisheries, industrial and urban development;
- Ensure appropriate resource-use planning and management;
- Ensure a long-term viable economic future for basin dependants;
- Safeguard self-maintaining populations of native species;
- Preserve cultural heritage;
- Maintain the tourism potential and develop linkages between tourism and conservation.

ICM strategies recognise that:

- Decisions need to be formulated in the context of a broad strategy that takes the long-term view, incorporates assumptions about the actions and reactions of all participants in water management, and fully considers the ecosystems and socio-economic structures that exist in an entire river basin;
- Solutions need to focus on underlying causes not merely their symptoms;
- Issues must be approached in an integrated way;
- In general, development of sound resource management and collective responsibility for resources will take place at the sub-regional or village level.

There is potential for multiple reuse of water within catchments, and that some water that is 'lost' at the household or field level may be reused. Protection of ecosystem services downstream in rivers may involve constraints on upstream water-use, both in terms of quantity and quality.

To be successful, ICM requires basic understanding about biological, physical, chemical and socio-economic systems and how they interact within a catchment. There is therefore a need for inputs from a wide range of different professions. Much can be learned about the success and failure of different management interventions from previous experience. By collating and analysing this experience, it is possible to synthesise current 'best practice' in the form of guidelines. For example, in the UK a framework has been drawn up to support the sustainable management of groundwater source abstractions. This provides a practical basis for strategic water resource planning (Acreman and Adams, 1998). Similarly, the Economic and Social Commission for Asia and the Pacific have developed guidelines for land-use planning and practices in watershed management and disaster reduction (UN, 1997). As noted in section 3.3.2, the World Commission on Dams, established in 1997, is currently assessing the experience with existing, new and proposed large dam projects in order to evaluate the development effectiveness of large dams. The development of such guidelines can highlight where absence of data or lack of knowledge requires further environmental monitoring or research, respectively.

Table 12 Tools for use in integrated catchment management

Tool	Description
Integrated water resource simulation models (IWRSM)	Computer models that enable water resource issues to be investigated in an integrated manner. Includes modules for simulating all aspects of the hydrology and water resource utilisation of a basin, including water quantity, water quality and hydro-ecology. Ability to model sub-catchments at a variety of scales, spatially and temporally.
Geographical Information Systems (GIS)	Organised collections of software and geographic data (temporal and spatial) designed to efficiently capture, store, update, manipulate, analyse and display all forms of geographic data.
Habitat models	Computer models that predict the change in habitat availability for key target species given changes in river flow, channel morphology, water quality and substrate. Can be used to assist in setting river flow objectives.
Information management	Modern advances in computers and associated databases provide a means of managing and manipulating data to maximise the knowledge and information to be gained for both research and operational management of natural resources.
Remote sensing	Advances in satellite images at a range of wavelengths provide opportunities both for use as a research tool to gain increased understanding of natural processes that affect the hydrological cycle and as an operational tool for management natural resources.
Environmental Assessment (EA)	Evaluates a project's potential environmental risks and impacts in its area of influence, examines project alternatives, and identifies ways of improving project selection, siting, planning, design and implementation by preventing, minimising or compensating for adverse environmental impacts and enhancing positive of impacts (World Bank, 1991).
Telecommunications	Provide means of transmitting data, knowledge and information rapidly around the globe. In the developed world, the capacity for data transmission is increasing exponentially as a consequence of increased bandwidth (fibre-optic cables, new satellite systems) as well as data-compression techniques. The internet provides a new medium for worldwide dissemination of data. However, for many people in developing countries, access to reliable telecommunications is difficult. Lack of communication impacts directly on people's security as well as placing a constraint on mitigation strategies (Quadir et al., 1999).
Decision Support Systems (DSS)	Similar to IWRSM, DSS allow decision-makers to combine personal judgement with computer output in a user-machine interface. Combine quantitative models and database elements for problem-solving, and it is claimed provide a comprehensive framework to balance water allocation between competing demands (Simonovic, 1996).

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In recent years, a range of technical tools has been developed to assist with ICM. Many other modern technologies can be utilised, either directly or indirectly, to assist with ICM (see Table 12). As noted above, key aspects of ICM are both to mitigate against change but also to adapt to inevitable change in freshwater ecosystems. These elements of ICM are discussed in the next two sections.

It is beyond the scope of this paper to provide detailed descriptions of these and many other tools available. However, in the following sections a range of technical solutions that can be used to assist in mitigation and adaptation are discussed.

5.2 Responses to mitigate threats to freshwater ecosystems and environmental security

Two broad types of mitigation strategy are recognised. Remedial actions are those which try to prevent degradation at the end of the line (e.g. by removal of pollutants at a treatment plant). Preventative actions are those which attempt to remove the cause of the problem (e.g. reduce the amount of chemicals used by farmers). Technology has a role to play in both approaches. It can help to increase the efficiency of use of resources, delivering equivalent or improved services while substantially reducing environmental burdens.

5.2.1 Mitigation measures that impact on water quantity

Although renewable, it is now recognised that fresh water is a finite resource. Heavy water consumption frequently leads to environmentally disruptive decreases in the level of water in many freshwater ecosystems (see Box 7). Only if human demands for direct utilisation of water can be restricted, or alternative water resources can be found, will more water become available for those freshwater ecosystems currently being degraded as a consequence of human abstraction.

Demand management

Demand management refers to actions for affecting the ways in which water is used. Demand management seeks to improve the efficiency of the direct use of water by people. It is increasingly coming on the agenda in regions where concerns have arisen over water sufficiency, allocation, high costs of expanding supplies and environmental preservation.

Worldwide, irrigated agriculture is by far the greatest direct consumer of water (see section 2.3). It is also the least efficient. Traditional surface irrigation generally achieves 40% efficiency. Modern technology can improve efficiency by improving the timing of delivery of water and by cutting the amount of water applied. Automated methods that measure soil water directly, and so ensure water is applied only when crops are stressed, are now available. Sprinkler irrigation can be 70 to 80% efficient and drip irrigation can reach over 90% efficiency (Wolff and Stein, 1998). These methods are expensive and require significant maintenance. Consequently they are inappropriate for many regions in developing countries. However, for subsistence agriculture, simple methods based on subsurface or pitcher irrigation have been developed (Batchelor et al., 1996).

Water supply and sanitation systems in many urban areas are characterised by high leakage and low efficiencies. A great deal of water is not returned directly (treated or untreated) to the source from which it was withdrawn. In some communities, such water 'losses' can reach 40-60%. In contrast, in modern cities with centralised water pipeline systems and relatively new sewage systems consumption does not usually exceed 5-10% (Shiklomanov, 1997). These figures demonstrate that actions to improve operational efficiency and reduce leaks could make a significant impact on water demand in urban areas.

An idea closely associated with efficiency of water use is the notion of efficiency of allocation. This is the idea that water should be allocated to those sectors from which the greatest economic returns are obtained. This is strictly an economic evaluation and is discussed in more detail in the paper on economic security (Swanson and Doble, 1999).

Water recycling

Recycling refers to the capture and reuse of water prior to ejecting wastewater to ground or surface water receptors. Hence, recycling reduces water withdrawal requirements for a given set of final uses. For example, end-use water requirements for an industrial process may be met totally by withdrawals in a once-through process, or by lower levels of withdrawals in combination with internal recycling which captures and reuses waste water. Similar considerations apply in the capture and reuse of water in municipal and irrigation systems.

Domestic wastewater has been used in irrigation for over a century in some countries, including Germany. Prudent management can considerably reduce health risks. At present, some 5,000 km² or 0.2 per cent of the world's irrigated farmland is watered using wastewater. Although it is probable that this figure will increase in the future, it is unlikely that it will increase above 1 per cent of the total irrigated surface area (Wolff and Stein, 1998).

Not all industrial and domestic processes require water to be of potable standard. For example, there is no reason why water used for toilet flushing needs to be of the same quality as drinking water. The use of recycled 'grey' water (i.e. wastewater that is not sewage) for non-potable uses is becoming increasingly common. For example, in California there are about 380 schemes, and a state ordinance requires that all large new buildings include dual plumbing (Surendran and Wheatley, 1998). The reuse of sewage is also being investigated. In a new housing development in Sydney, tertiary-treated and disinfected sewage effluent has been connected to toilets and external taps (Mills and Asano, 1996).

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Desalination

The production of 'new' fresh water by desalinating sea water has attracted much attention in recent years. In Kuwait, desalination (six desalination plants with maximum capacity of 950,000 m^3d^{-1}) is the primary source of fresh water for drinking and domestic purposes. The quantity of desalinated water produced in Kuwait in 1993 was 231 million m^3 (Green Cross International, 1998). In Morocco, a 10 megawatt (MW) nuclear power station is being built to provide electricity for a desalination plant that will provide water for 70,000 people (George, 1999).

However, at present only 0.1 per cent of human wateruse is supplied by desalination. This is because it is energy-intensive and hence expensive. The theoretical minimum energy requirement to remove salt from water is 2.8 million joules per cubic metre, but even the best desalination plants now operating use 30 times this amount (Postel et al., 1996). Nevertheless, in recent years technological advances have caused a significant decline in the costs of desalination. For new plants the cost is about US$ 1 m^{-3}. In California, new plants have become operational to desalinate brackish water at a cost of US$ 0.5 m^{-3}. It is anticipated that improved technologies in the future (e.g. improved exploitation of solar energy) could reduce the costs to the extent that desalination becomes a relatively small component of the overall cost of urban water supply and sanitation. However, it is unlikely that desalinated water will be used extensively for irrigation in the near future.

Water harvesting

Water harvesting is the direct capture of rainfall or collection of surface runoff to use as drinking water and to water crops and livestock. In some circumstances, traditional methods of harvesting water may present opportunities for relieving water shortages in arid areas. Techniques include:

- the capture of rainfall draining from the roofs of buildings;
- tanks to capture surface runoff;
- low earth embankments built across drainage channels to divert runoff onto fields;
- bunds constructed on fields to promote the infiltration of surface runoff.

Such practices generally do enhance the efficiency with which precipitation is used. However, whether water-harvesting measures improve the efficiency of water use in a catchment area as a whole depends on local conditions. For example, too much water retention in the upper part of a catchment can reduce the water yield lower in the catchment, creating the risk of water shortages for users downstream (Hollis, 1986).

5.2.2 Mitigation measures that impact on environmental security

Human-induced changes in the quality of fresh water can have a very large impact on environmental security. For example, disposal of industrial wastewater and untreated sewage in the Indian city of Ludhiana has contaminated wells with chromium and cyanide and so jeopardised future development of groundwater, the only source of drinking water for the city (Singh, 1998). Contamination of water can also have very serious consequences for freshwater biota. There are various mitigation measures that improve water quality.

Wastewater treatment

Treatment of wastewater is an end-of-pipe solution to the problem of contaminated water. As mentioned in section 3.5.3, dramatic increases in environmental security were obtained in the developed world in the 1800s through the introduction of treatment of industrial and municipal effluent. New technologies, such as ultraviolet treatment, have been developed to improve the quality of effluents discharged to freshwater ecosystems.

In recent years, the use of wetlands to 'passively' treat polluted discharges has been widely proposed, and in places attempted. In the USA, 300 artificial wetlands treat polluted mine discharges, and the approach is becoming increasingly used in Europe. In the UK, eight systems have been installed. These wetlands are designed to mimic the waste assimilation and self-purification functions of natural wetlands. Such wetlands are ideal in situations where chemical treatment of diffuse source pollutants is very expensive. The wetlands are currently designed for function rather than form, but it is hoped that in future it will be possible to integrate them as far as possible into the natural ecological systems of catchments (Younger et al., 1998).

Watershed and groundwater resource protection

Production of potable water depends on three things: watershed protection, filtration and disinfection. In the past, watershed protection – which attempts to keep pathogens and pollutants from entering the water, rather than killing or removing those that do – has received scant attention. Instead, as new threats emerged, engineering solutions were introduced. New technologies – such as airstripping to remove volatile organic pollutants from groundwater, activated carbon filtration and ozone disinfection – were devised. However such treatments are very expensive and watershed protection is proposed as a non-engineering alternative in some cases (see Box 10).

The principle is that potentially polluting activities are prohibited or restricted in water source areas. In Europe and the USA, the source protection zones may be complex and relatively large. They are often divided into two or three sub-zones, and the most severe restrictions applied only close to the source. Strips of vegetation along streams and around reservoirs are also important buffers in both urban and rural settings. These buffer zones demonstrably lessen the amount of pollution entering the water system. Similarly, protection around individual wells may be used to protect water abstraction points.

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Box 10 USA

Watershed protection in New York

New York City has set aside US$ 250-300 million for land acquisition as part of an integrated strategy to protect water supplies from pollution. The intention is to purchase some 80,000 acres of the land, more if necessary, in order to protect water sources. Watershed regulations are also being expanded to address things like the construction of roads and parking lots – i.e. impervious surfaces – close to reservoirs and watercourses; storm-water runoff; the unprotected storage of highway salt; and rigorous standards for sewage handling. Special attention is being given to septic systems of which there are 130,000 in New York's watershed. Many of these will be closed and strict standards set for the construction of new ones. Homes and businesses will be connected to newly constructed, city-subsidised tertiary treatment plants. Total investment in the strategy is US$ 1.5 billion. However, by protecting the water sources that supply New York from pollution, the city is able to avoid constructing a water filtration plant that would cost US$ 6-8 billion and would incur annual operating costs of US$ 300 million.

Source: The Trust for Public Land, 1997

In developing countries, community water supplies in rural areas are rarely treated, but sloping concrete aprons around well heads to prevent spilled water leaking back into the well, and the prohibition of animals from the area immediately around a water source, can significantly reduce the risk of pollution. A circular protection zone of 50-100 metres in radius can be introduced to reduce the risk of pathogenic contamination. Within this zone pit latrines, septic tanks and other potential sources of contamination are not allowed.

5.2.3 Habitat protection

As demonstrated in section 5.2.2, protected areas can play a central role in developing strategies of water management. People can benefit directly from the protection of downstream areas as well as catchment headwaters. For instance, the protection of downstream ecosystems may conserve critical fisheries, floodplain forests or pasture. Moreover, the idea of protecting 'natural' ecosystems for no other reason than that they exist is becoming an increasingly popular societal preference in developed countries. Studies have shown that people in these countries are 'willing to pay' simply to know that such places exist, even if they will never visit them and they gain no direct benefits from them (Barbier et al., 1997). This suggests that once a certain level of social and economic security is attained, people seek 'ethical security' through the protection of near-pristine environments.

Frissell and Bayles (1996) propose the establishment of 'watershed reserves.' They argue that these reserves should constitute a network of the 'best-remaining' examples of relatively unaltered ecosystems and aquatic communities. In extensively altered landscapes, they suggest that these would need to be supplemented or replaced by the 'least-disrupted' ecosystems that retain much of their ecological value and hold good promise for relatively rapid and cost efficient restoration. Such a reserve network would ideally "encompass a regionally representative range of terrestrial and aquatic ecosystem types and natural successional conditions, and incorporate areas that have especially high ecological integrity or natural diversity, high incidence of rare or seriously declining aquatic and riparian species and assemblages, and relatively unimpaired natural-historical catchment-wide biophysical processes and disturbance regimes." They propose that the network would provide a fallback position against uncertainties about the success of future management manipulations of ecosystems that are bound to have unanticipated and unforeseeable consequences. The reserves would serve this purpose in four ways. First, they would ensure that the same mistakes would not be made everywhere. Second, they would provide necessary and appropriately-scaled scientific controls against which the ecosystem management strategies might be assessed. Third, if selected as described above, they would represent the areas where the greatest share of biotic resources can be protected with limited resources. Finally, they would provide the best possible living models for the development of truly restorative ecosystem management on severely altered parts of the landscape.

5.3 Responses to adapt to changes in freshwater ecosystems and environmental security

ICM is supposed to be a flexible and adaptive management approach. The need for development is recognised and so adaptation strategies are a key element of ICM. The principle of 'no net loss' is one that may in future become increasingly called upon when assessing development strategies. The principle stipulates the need for compensation for loss of ecosystems through measures to create, restore or improve a similar nearby area if a freshwater ecosystem is degraded or destroyed as a consequence of development. It is often a costly option and at present is only applicable to certain forms of freshwater ecosystem.

In this section, the restoration of ecological services in altered systems and the idea of utilising biotechnology to adapt to changes in freshwater ecosystems are discussed.

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5.3.1 Restoration of ecological services

Altering operation and decommissioning dams

Reservoirs, if properly managed, meet one of the key requirements for environmental security, namely long-term sustainability. The water can be used only once and it is then necessary to wait for the next season's rainfall before refilling, thus it cannot be overexploited. However, as discussed in section 3.3.2, dams do have negative environmental consequences. They drown the river upstream of the dam and they replace the natural cycle of floods and low flows with a more constant flow related to downstream supply requirements and electricity demand. These changes, in addition to destroying wildlife habitat, can have serious implications for the environmental security of people living in the catchment.

However, setting aside some reservoir volume to mimic critical environmental flows can in part reduce the negative aspects of dams. For example, it is now common practice to stipulate minimum 'compensation' flows in rivers in order to maintain dry season base flows, and the idea of releasing 'artificial' flood flows (sometimes termed freshets) to inundate floodplains at critical times of year is becoming more widely promoted (Acreman, 1996). For example, on the Kafue River, control rules for the operation of the Itezhi-tezhi dam stipulate that a minimum flow of 25m^3s^{-1} must be maintained all year and a release of 300 m^3s^{-1} must be released for 4 week period in March each year in order to flood the ecologically-important Kafue Flats.

It is also possible for management strategies to be introduced to compensate for the truncation of sediment transport. For example, on the upper Rhine, gravel is added to the channel to compensate for reduced sediment transport arising as a consequence of upstream impoundments. This intention is to reduce bed degradation and maintain groundwater levels (Dister et al., 1990 – cited in Ward and Stanford, 1995).
To be successful, the preservation of freshwater ecosystems must be given high priority within whatever management strategy is adopted or else, when water is scarce, dam operators will tend to use the water in ways which do not protect the downstream ecosystems.

An alternative to operation of dams to preserve downstream ecological functions, and one which is increasingly being considered in the USA and Europe, is the decommissioning of dams. In 1997, the US federal government refused to relicense an existing dam for the first time ever. The reasons given were that the benefits to be obtained by removal outweighed those that accrued from continued presence of the structure (see Box 11). It is important to note that decommissioning dams can itself cause environmental problems. For instance, the washing of sediments previously stored behind the dam into the river may cover fish spawning areas, damage river habitats (particularly those of species that are happier in still water) and change the shape of the river. These problems may be compounded by the fact that the sediments are often toxic.

Box 11

Decommissioning of the Edwards dam, USA

When in 1997 the Federal Energy Regulatory Commission (FERC) in the USA ordered the removal of the Edwards dam (built in 1870) it cited 'compelling environmental' considerations. The Commission said its actions were based on the following key considerations:

- **power produced at the dam can easily be replaced by existing resources in the region**
- **removal will provide 9 species of fish with continuous access to 15 miles of spawning habitat**
- **removal will provide 4 species of fish that do not use fishways with access to their entire historic range within the Kennebec river**
- **wetland habitats, recreational boating and fishing will benefit**
- **there will be no major environmental or social drawbacks**

Rehabilitation and restoration of freshwater ecosystems

Restoration refers to the process by which freshwater ecosystems are returned to what is regarded as a more natural or less-disturbed state. It aims at "the full or partial replacement of structural or functional characteristics that have been extinguished or diminished and the substitution of alter native qualities or characteristics than the ones originally present with the proviso that they have more social, economic or ecological value than existed in the disturbed state" (Cairns, 1986). A distinction can be made between restoration, which is any activity that aims to return a system to the condition it was prior to the disturbance (regardless of whether this was pristine), and rehabilitation, defined as any activity which aims to convert a degraded system to a stable alternative use which is designed to meet a particular management objective (Frid and Clark, 1999). Restoration is usually regarded as having a well-defined end point (i.e. the status of the system before it was degraded). However, it is very rarely possible to return ecosystems to their original condition.

A key goal for science is to establish the appropriate mechanisms and the level of support required to restore freshwater ecosystems to a desired natural or artificial state. Progress is being made in developing relationships between hydrological change and habitat for biological indicators (Petts, 1996). These will enable evaluation of the ecological effects of change. However, although models exist (e.g. PHABSIM), they are at present imprecise and remain largely qualitative in nature. Furthermore, even when quantitative data are available, the decisions on the 'acceptability' of a particular ecosystem state depend largely on value judgements. A major challenge of restoration of freshwater ecosystems is the need to integrate scientific knowledge with those economic and social pressures that have a direct impact on the system.

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Schemes for restoring or rehabilitating freshwater ecosystems will be most successful if consideration is given to the following (adapted from Wade et al., 1998):

- clear goals and objectives must be identified at the outset;
- schemes are adaptive and flexible;
- maintenance costs in the long term are kept to a minimum;
- the scheme is suitable for existing climate and hydrological regime;
- the scheme can cope with, indeed is designed for extreme events as well as average conditions;
- all stakeholders are included in the design process;
- it is recognised that schemes will not become functional instantaneously;
- schemes are designed for function and not form;
- schemes are not over-engineered, but are as natural as possible.

There is a need for monitoring to determine if restoration projects are effective. Three types of monitoring have been identified as appropriate (Kershner, 1997): implementation, effectiveness and validation. Implementation monitoring identifies whether the restoration measures are functioning as intended. Effectiveness monitoring determines if the restoration is meeting the objectives identified at the outset of the scheme. Validation monitoring is primarily a research activity, used to gather information on the basic assumptions needed to develop objectives.

5.3.2 Biotechnology

Advances in biotechnology may lead to the introduction of drought, salt and pest resistant crops, thereby increasing crop yields and allowing expansion of potentially arable land. It is likely that within the next 5 to 7 years, the functions of most of the genes that are in plants will be known. With this knowledge, it is surmised that it may be possible to develop transgenic plants that are more tolerant to drought and salinity stress (Panel on Biotechnology of the Water Commission on Water, 1999). In 1996, there were 7 million acres of transgenic crops in the world. There were 31 million acres in 1997, and over 75 million acres were planted in 1998. If this trend continues, rain-fed agriculture may provide the most effective way to expand food production on a global scale with a consequent decrease in projected irrigation withdrawals.

Although biotechnology options have potential, there remain two significant problems. First, despite numerous studies conducted there is still only limited knowledge of the physiological, biochemical and genetic determinants of stress in plants, and a great deal more understanding is required before DNA modification can be used to manipulate water and salinity stress resistance. Second, recent events in Europe suggest that biotechnology is treated with suspicion and it may be that genetically-modified organisms are unacceptable to some societies.

5.4 Synthesis: Impediments to future strategies

In the past, improvement in environmental security in the developed world has been dependent to a large extent on the application of technology. Existing and new technologies will have a role to play in increasing environmental security in the future. However, it is now widely recognised that, while freshwater management has traditionally been governed by 'supply side planning' or utilisation of engineering solutions to manage the resource to meet levels of projected, and often unregulated demand, such an approach is not sustainable in the long term. ICM, a new approach based on the ethic of ecosystem management, is now being widely promoted.

The environmental security indicators presented in section 3.5 indicate that priorities in the developed and developing world are very different. In developing countries, the emphasis must be on 'elementary environmental care' mostly oriented to meeting the basic water supply, housing and waste disposal needs. In the developed world, the emphasis must be on protecting the few remaining near-pristine freshwater ecosystems, ameliorating the impact of existing development and introducing management strategies to restore degraded ecosystems. Although the priorities are different, the basic doctrine proposed within the concept of ICM applies to both developed and developing countries.

There are at present considerable technical difficulties to the practical application of ICM principles. These can be summarised as follows:

- Successful ICM schemes are dependent on understanding the cause-and-effect linkages between land-use patterns, hydrological regime and biotic response. To a large extent these relationships are not understood. There is a need for increased research to develop quantitative useable relationships between these three components of freshwater ecosystems.
- There is a great deal of potential for societies to improve the efficiency of direct use of water. However, the interest in demand-side management is new, and the required database for analysing water-use patterns in detail in order to formulate sound demand-management programmes are in many places sparse.
- Monitoring programmes are important in ICM because management strategies must be adaptable. However, such 'effectiveness' monitoring is time consuming and costly. Many current monitoring programs are inadequate, for a variety of reasons, and do not provide information that is useful for ICM.
- Successful ICM strategies must integrate environmental, social and economic factors. However, there are very few practical methods for directly linking these different aspects of freshwater ecosystems.

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- Good scientific analyses often make decision-making more difficult because they highlight critical uncertainties arising from the complexities of ecology and the history of human interventions. Consequently, it is not clear how science should be incorporated within the decision-making process.
- Many of the world's major river basins lie across national borders. At present, no enforceable law governs the use of shared watercourses. However, in the last century various multilateral treaties and conventions have been established to cover specific river basins or lakes (e.g. the Indus, Niger, Senegal, Zambezi, Rhine, Danube and Lake Victoria). A key problem with most of these international agreements is that their success ultimately depends on a convergence of interests between sovereign states. As a result, treaties incorporating detailed targets and structures often take many years to draft and even longer to ratify. The growing sense of urgency in addressing complex problems has led to a shift to softer treaties which can be drafted and signed within a relatively short time frame. These may include codes of practice or general frameworks that allow wide discretion in interpreting their precise requirements. Thus, they are easier to agree to, but their flexibility can reduce their effectiveness.

Overcoming these impediments is essential if ICM is to provide a basis for freshwater ecosystem management and the enhancement of environmental security in the next century.

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6. Final Statement

Freshwater ecosystems are inherently complex, comprising many interdependent components. History has shown that human activities undertaken without full consideration of the social, environmental and economic implications can, and do, have adverse repercussions. Management practices that respond to a single water use, a single population segment, or a single sector have caused inadvertent disruption to ecological functions and resulted in a net loss of environmental security. Comprehensive management strategies that recognise the interdependencies existing within freshwater ecosystems are required in order to maximise benefits accrued by society and so increase environmental security.

Ecosystem management represents an ill-defined basis for resource management. To be technically credible, the term must be defined in much narrower policy and scientific terms. Nevertheless, it does provide a valid water 'ethic' on which freshwater management can be founded. As we approach the 21st century, the main challenge is to put the general principles of ecosystem management into practice. It is suggested that the multi-objective goals relating to society, economics and the environment can be integrated within catchment management strategies, but many problems remain in deriving practical approaches to doing this.

It is clear from the analysis presented in this document that environmental security issues are multiple and complex. Environmental degradation and resource depletion creates or exacerbates human insecurity. Currently, the environmental security problems in developing countries are very different to those of the developed world. In developing countries, the future emphasis must be on 'elementary environmental care' mostly oriented to meeting basic water supply, housing and waste disposal needs. Appropriate technical solutions exist and have a crucial role to play in increasing security in these countries. These must be applied within the context of management strategies that safeguard the environment and protect the natural resources on which so many people, particularly the rural poor, depend.

In the developed world, high levels of social and economic security have been obtained through application of complex technologies and considerable alteration of natural ecosystems. These societies are now sufficiently prosperous that they can contemplate a large range of possible options on the way they manage freshwater ecosystems. In these countries, societies are placing greater value on the indirect benefits of near-natural freshwater ecosystems, to the extent that costly rehabilitation schemes and the establishment of reserves that provide no direct benefits are being increasingly implemented.

In both developing and developed countries, successful management of freshwater ecosystems requires an integrated approach drawing upon the expertise of multidisciplinary teams. Much can be learned from local resource management based on traditional practice. Although there are limitations, nevertheless river catchments provide the most logical, easily identifiable hydro-geomorphologic unit on which to base management strategies. ICM has been developed to provide a framework for action. Management strategies must be adaptable and flexible to meet constantly changing environmental conditions and human demands. As this paper has illustrated, ingenious solutions are often required to solve complex problems. Scientific and socio-economic monitoring is essential to further understanding of cause-and-effect relationships both within the natural environment and in human interactions with the natural environment.

In summary, increasing environmental security requires that:

- issues of environmental change and security are dealt with holistically. Management strategies must be conceived, designed and implemented with a clear appreciation of the interconnectedness of poverty, environmental change and security;
- management strategies satisfy both immediate and long-term needs;
- research findings are used to provide an analytical perspective of problems, guide policy-making and inform assessments of management interventions;
- resources are directed towards identifying vulnerable geographical regions and sectors of society, and promoting adaptation and resilience in both;
- the impediments to ICM summarised in section 5.4 are overcome.

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6.1 Issues for discussion at the workshop

The objective of the San José workshop is to develop practical strategies that move towards the vision provided in the 'sustainable water world' scenario. Box 12 lists a number of issues that might be discussed at the workshop.

Box 12

Issues for discussion

- Biodiversity is sometimes a benefit and sometimes a constraint on human development. How do we assess when it is acceptable to sacrifice biodiversity and when should it be retained? Is this simply a question of societal preference?
- Should environmental security (i.e. protection of the environment for human benefit) and ethical security (i.e. a moral duty to protect the environment from human interference) be treated as separate issues? The distinction between the two has perhaps been blurred by conservationists but surely they are quite separate.
- Is it the case that, at present, planning for ecosystem management remains largely focussed on defining how and where traditional resource extraction activities and environmental disruption can be continued without irreversible damage to water quality, biodiversity and other ecosystem values? As such, is it simply a search for the last 'free lunch'? Is something more required?
- Is it the case that attempts to meet multiple conflicting and changing needs simply result in continual compromise and gradual degradation of natural ecosystems?
- Is it true that all very 'artificial' freshwater ecosystems are non-sustainable over the long-term, despite our best management efforts?
- Is it necessary to do more than 'integrate' water and landuse? Should the idea of 'water management' as a legitimate land use (i.e. as in the case of New York) be more widely promoted?
- What are the tools necessary to effectively implement freshwater ecosystem management so as to maintain and/or enhance environmental security?
- Recognising that it is impossible to know everything about the structure and functioning of an ecosystem, is it possible to define what we must know in order to effectively manage them to maintain and/or enhance environmental security?

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Glossary

Aquifer: Porous rock containing water
Catchment: Used synonomously with watershed, river basin or drainage area. It is the unit of land from which water flows downhill to a specified point on a watercourse. It is determined by topographical features which include a surrounding boundary or perimeter known as a drainage divide or catchment boundary.
Connectedness: A general term for the cohesiveness of a system. Systems with strong interaction are relatively highly connected, as are systems with a large number of the parts interconnected.
Connectivity: A measure of the degree of connectedness of a system
Degraded ecosystem: An ecosystem that has lost some or all of its direct or indirect value to human society.
Ecosystem: A discrete entity that consists of living and non-living parts, interacting to form a stable unit.
Ecosystem management: deliberate and conscious manipulation of ecosystem structure and/or function, or regulation of human uses of ecological systems, so as to retain defined and desired features and processes, and to meet human needs in an optimal and sustainable way.
Environmental Security: A means of achieving long-term social, economic and ethical security through: i) the sustainable utilisation of renewable resources and ecosystem functions; ii) protection from natural hazards and iii) conservation of other species.
Integrated Catchment Management (ICM): The co-ordinated planning and management of the water resources of a river basin considering its interaction with land and other environmental resources for their equitable, efficient and sustainable use at a range of scales from local to catchment level.
Integrity: The continuity of a complex and the totality of its locations within some order.
Robustness: The property of remaining unchanged even under the influence of new forces, new data or new perspectives of observation.
Resilience: A measure of the magnitude or scale of disturbance that can be absorbed before a system changes in structure by the change of variables or processes that control system behaviour. Resilience in this context is a measure of robustness and buffering capacity of the system to changing conditions.
Rehabilitation: The conversion of a degraded ecosystem to a stable alternative use, designed to meet a particular management objective.
Restoration: The conversion of an ecosystem to the condition it was in prior to anthropogenic disturbance.

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Freshwater Ecosystem Management &

Environmental Security

Final Statement and Workshop Report

Chair:

Max Campos

Technical Coordinator:

Ger Bergkamp

Regional Coordinator:

Rocío Córdoba

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Final Statement

Vision for Water and Nature Workshop, San José, Costa Rica, June 20 - 22, 1999

Vision

A world in which everyone values and accepts personal responsibility to conserve and judiciously utilise freshwater ecosystem resources and functions; where benefits to humankind are optimised while ensuring that there shall be no further losses of these freshwater ecosystem resources, functions and biodiversity.

The achievement of this Vision necessitates the establishment of social, economic, political and legal conditions that enable humankind to live up to its moral and ethical obligation to protect biodiversity. It also requires the promotion of environmental security – a state in which human well-being is supported by the resources and environmental services provided by healthy and productive ecosystems. The equitable distribution of environmental security is what most influences the extent to which social aspirations, economic goals and ethical commitments of both present and future generations can be met.

Challenges

In addressing the emerging problems the world is facing regarding freshwater resources and the ecosystems on which these depend, it is becoming clear that societies do not have a choice but to face the challenges. If societies are to establish a sustainable world, both human and environmental needs must be fully considered.

Rational use of resources

A major challenge is in preventing further loss of ecosystem functions, restoring ecosystem functions where these have been lost and reducing water quality degradation. This requires finding enough space for people and natural ecosystems, and allocating sufficient water to meet both the needs and rights of ecosystems and people. Achieving equitable allocation is especially challenging where water bodies cross political, cultural or socio-economic group boundaries and where uncertainty in resource availability is high due to a changing climate.

Conservation and protection of ecosystems

Implementation of ecosystem protection and wise use within integrated river basin management (IRBM) schemes is a challenge that requires characterising resource use pressures on freshwater ecosystems, and analysing the economic, social, cultural and environmental interactions in a holistic and integrated way. Crucial for this is implementation of management schemes that incorporate the protection of strategic and/or unique natural ecosystems, including the populations that depend on these. A further major challenge is the improvement of water quality in many freshwater ecosystems through integrated pollution control.

Participation and responsible behaviour of societal groups

Providing all human individuals and groups with equal opportunities for meeting their basic water needs and sharing in the benefits from freshwater ecosystems constitutes a main issue to be tackled in the coming decades. It will require the recovery of the sense of identity, responsibility and solidarity towards water and freshwater ecosystem use, and commitment to become involved in their responsible management. Integrated river basin management holds the challenge of establishing effective participation in the decision-making and management process, aimed at consensus-building through convening multidisciplinary expert groups and stakeholders and exchanging information. The empowerment of women and youth to participate in safeguarding freshwater ecosystems, and respecting the rights of ethnic and traditional communities to maintain integral lifestyles, are key challenges within this process.

Strengthening of water resources management institutions

Establishing new or strengthening existing suitable independent institutions or institutional mechanisms responsible for implementation of effective freshwater ecosystem management at river basin levels forms a major challenge to be faced. River Basin Commissions/Committees, River Basin Authorities, non governmental organisations (NGOs) and community-based organisations (CBOs) will need to establish and strengthen institutional cooperation, develop linkages with all stakeholder groups, and set up and maintain structures that ensure transparency, independence, accountability, democracy and use of best knowledge.

Establishing the political commitment for change

Reforms of current sector-oriented policies and establishment of integrated water management policies at local, national and international levels are important challenges that need to be addressed. To bring about this change, considerable political will and commitment need to be developed to initiate and maintain good governance aimed at integrated water management within river basins and conservation of freshwater ecosystems.

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- **Development and enforcement of laws and agreements**

Harmonising, updating and enforcing legislation at regional and national levels forms a major challenge. Cooperation between countries that share transboundary freshwater ecosystems is a particularly important issue that will require the definition of adequate management programmes and equal water access rights. Ratification, implementation and monitoring of international conventions is key to ensuring global environmental security.

- **Development of sustainable funding mechanisms**

Providing sufficient funding to resist overexploitation and ecosystem degradation represents a major challenge for water management in the next decades. Increased globalisation of markets will require that more effective and efficient ways be sought for financing sustainable development and ecosystem conservation and restoration, including private sector investments. Establishing financial resources to develop integrated river basin management is a challenge that needs to be addressed before progress can be made. It is essential to ensure that all funds are used effectively and are targeted at projects that will achieve sustainable improvements in environmental security.

- **Facing the economic realities of the next millennium**

An important challenge lies in the internalisation of the economic and ecological value of water in decision-making processes and water management. Many current economic policies and instruments, such as perverse subsidies, distorted prices and taxes, stimulate freshwater ecosystem degradation and excessive freshwater extraction and pollution. Policies, guidelines and economic instruments that provide incentives for sustainable freshwater ecosystem management are needed. Addressing the economic implications of ecosystem degradation and loss of environmental security from global to local levels forms an opportunity for addressing these challenges.

- **Development of innovative science and technology**

Developing rapid and inexpensive methods for functional assessment of freshwater ecosystems is a key challenge that requires the definition of links between loss of function and loss of human benefits and water needs of particular species and ecosystems. Also challenging is the need for innovative, preventive, affordable and environmentally-sound technologies for water management, which are based on local indigenous knowledge and scientific expertise, and applied to use resources sustainably and safeguard communities against extreme events. A challenge is to establish water quantity, quality and flow regime requirements to sustain freshwater ecosystems and biodiversity or rehabilitate degraded systems.

- **Maintenance of information flows**

The collection and storage of baseline hydrometeorological, ecological and sociological data is a particular challenge for societies and responsible organisations in particular. To address this will require cost-effective data gathering (e.g. using GIS and remote sensing), and the set-up of new and maintenance of existing networks of monitoring sites and data-collection schemes. Making this information equally available, openly accessible, and communicated to interested parties at all levels through development of appropriate exchange mechanisms with interested stakeholders, expert groups and NGOs/CBOs, forms a big challenge. It will require a process of information capacity-building based on popularisation of scientific studies and indigenous knowledge sharing.

- **Implementation of effective education and communication**

Limits in human resources and capacities in freshwater ecosystem assessment and management, and integrated river basin management, constitute major challenges to be tackled by the education community at all levels. A particular challenge is the education of the general public, women, technical people and decision-makers on the ecological and economic values of freshwater ecosystem goods and services. Important are the views and perspectives of local people, which need to be respected and explained to decision-makers and technical experts. A major challenge is effective communication amongst scientists, decision-makers and local groups. Major financial resources are required to address this challenge.

Principles for Water and Nature

Care for fresh water – it is vital for life

Water is the life-blood of the Earth and all living organisms. It is a universal solvent and provides the major pathway for the flow of sediment and nutrients. Through erosion, transportation and deposition by rivers and glaciers, water shapes the landscape; and through evaporation, it drives the energy exchange between land and the atmosphere, thus controlling the Earth's climate. But water is a finite resource whose economic and ecological value must be included in all decision-making.

Foster ecosystems and their biodiversity – they are our future

The quantity, quality and natural variability of water must be maintained to protect the ecosystem functions on which humans depend. The characteristics and human use of ecosystems varies considerably, and priority must be accorded to the protection of unique or strategic ecosystems. The economic implications of ecosystem degradation and loss of environmental security should be both globally and locally addressed. The beliefs and rights of all communities, including ethnic and traditional communities, should be respected in water resources planning and management.

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Use fresh water fairly – take responsible action together

All people must have equal opportunity to meet their basic water needs and be equally involved in benefits created from the collective natural resource. Revising, harmonising, updating and enforcing water laws at regional and national levels, as well as with neighbouring states, is essential. People and organisations should accept responsibility, based on the active participation of all stakeholders, including local communities, multidisciplinary expert groups and corporate citizens, in the planning and management of freshwater ecosystems. Empowerment of women is central to the safeguarding of water and ecosystems in the new millennium.

Share freshwater secrets – exchange them and make wise decisions

Information is power. Long-term environmental data sets must be collected, made equally accessible to interested parties at all levels and used in planning and decision-making. Results of scientific studies must be popularised to be accessible to local people, and indigenous and local knowledge must be used in the decision-making process. Best scientific advice should be sought from multidisciplinary teams for decision-making. When information is inadequate the precautionary principle should be invoked.

Educate people about fresh water and ecosystems – understand and act wisely

Education is required at all levels, from schoolchildren to politicians. The sense of identity, responsibility and solidarity towards water use and freshwater ecosystem conservation must be recovered. Women and schoolteachers play a crucial role in local-level education on wise use. Training of students, professional staff and policy makers on the need for freshwater ecosystem conservation if furthermore essential.

Strategies

1. Encourage rational use of resources

- Governments, research groups, NGOs and private sector groups to develop instruments for integrated, multifunctional land-use planning and decision-making based on a long-term vision;
- Civil society groups, governments, river basin organisations, donors and investment banks to facilitate and support the implementation of river basin agreements and policies based on appropriate staffing provided by governments and considering gender differences;
- Governments, international agencies and NGOs to develop intersectoral consensus on river basin management and establish arbitration mechanisms.

2. Promote conservation and protection of ecosystems

- Private sector to act responsibly as good corporate citizens through abiding by regulations and co-funding awareness raising;
- Governments, NGOs and donors to implement EIA based on improved standards and adjusted legislation;
- Governments to manage, and private sector to conduct, EIA for river basin interventions.

3. Include all components of society in decision-making

- Governments to involve civil society groups in a structural way in the decision-making process, with a particular attention to the role of women (e.g. through a 50-50 quota);
- Governments and NGOs to consult local people during the entire project cycle, and CBOs and private sector groups to act as responsible citizens in participating in dialogue;
- NGOs to raise awareness of the important role of women in IRBM, and the need to empower them;
- NGOs and CBOs to support governments in establishing a participatory process for defining and implementing river basin agreements and policies.

4. Develop new and strengthen existing institutions

- Governments and NGOs/CBOs to create new and strengthen existing river basin authorities through provision of services by national governmental institutions, and development and implementation of management tools;
- River basin authorities to develop and implement river basin management plans and empower CBOs in river basin level decision-making.

5. Influence political will to make freshwater ecosystem management a priority

- Civil society to demand more accountability of local and national decision-makers and demand legal requirements for civil claims and public hearings;
- Civil society to accept responsibility for actions when agreeing to participation;
- NGOs to form a bridge between different actors within the political processes on resources management by convening meetings and disseminating information;
- NGOs and CBOs to develop effective exchange and coordination mechanisms to develop political pressure to implement integrated river basin management;
- NGOs to pressure signatories of the conventions to implement the conventions.

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6. Incorporate freshwater ecosystem concerns into legal framework

- Lawyers and NGOs to train judges on ecosystem services and legal aspects of ecosystem management, and property and access rights;
- Governments, with assistance of NGOs and lawyers, to develop legislation on environmental management and punishment for degradation;
- Lawyers to develop, governments to ratify, and state agencies and river basin organisations to implement IRBM agreements that aim at providing environmental security and maintenance of freshwater ecosystems, and develop appropriate policies that have a long-term view and are formulated through stakeholder participation, including women and youth;
- Lawyers, in collaboration with multidisciplinary teams, to harmonise binational, regional and international agreements related to water and land resource management and property and access rights, and to formulate model agreements based on 'best law practices' derived from case studies.

7. Develop innovative financing strategies

- Governments, supported through incremental cost payments by donors, to establish new or adapt existing infrastructure so that freshwater ecosystems continue to contribute to environmental security.

8. Develop and employ 'green' economic measures

- Private sector to develop a more longer-term vision and internalise externalities using, for example, the polluter-pays principle, company auditing and environmental reporting;
- Governments to develop green accounting procedures, develop green funds and tax incentives, and develop more effective use of limited available funds;
- NGOs, research groups and governments to develop and apply regional economic instruments and incentives;
- Donor and financial institutions to harmonise aid programmes and promote ecosystem management at the river basin level, with the assistance of international organisations, and co-finance major river basin development and restoration projects.

9. Intensify scientific research and develop new technologies

- Scientists to develop better methods for ecosystem assessment to increase our knowledge of water needs of ecosystems, including methods to reduce natural disaster impacts;
- Governments and donors to provide more research funding for freshwater ecosystem and river basin research with ear-marked funds for dissemination of results;
- Research groups, universities and private consultants to gather, analyse, synthesise and disseminate information to improve understanding and appreciation of ecosystem functions;
- Research groups, governments and NGOs to develop State of the Environment reports and other ecosystem assessments that are based on pilot projects and basin-wide studies, structured according to river basins, and are published in both scientific and popular formats;
- Research networks to build consistent approaches in data gathering, analysis and reporting through exchange of experience and specifically designed programmes;
- Research groups and NGOs to develop and adapt existing technologies for ecosystem-based water management and develop new appropriate technologies.

10. Improve collection and dissemination of information

- River basin authorities and other responsible organisations to be compelled to collect long-term data, manage data sets and disseminate the data to all interested parties; governments and donors to provide adequate funding for this, and lawyers to develop legislation;
- Government agencies to maintain existing and set up new systems to monitor freshwater ecosystems and water quantity and quality, status and trends, including coastal zone conditions, with support of private sector, donors, investment banks and governments;
- NGOs to develop and disseminate information on river basin management and freshwater ecosystem conservation, and advocate reaching consensus on planning and management of interventions;
- Governments, research institutions, universities and NGOs to develop shared data bases and monitoring/early warning systems on natural disasters phenomena;
- Governments, lawyers and international organisations and conventions secretariats to develop harmonising and collaborative mechanisms between environmental and water conventions.

11. Improve education and communication on freshwater ecosystem issues

- Universities and NGOs to train engineers, environmental managers and scientists to work in multidisciplinary teams, based on an adjustment of existing curricula and development of specific training modules;
- Civil society to be educated further on ecosystem values through a well-targeted education programme that puts particular emphasis on women;
- Scientists to improve communication of the results of research to civil society, private sector and government;
- Engineers to be educated and trained in ecological concepts and provided with examples of ecosystem values and guidelines for management of freshwater goods and services;
- Lawyers and NGOs to raise awareness on the New York Convention (1997) and NGOs to campaign for the signing of the Convention before May 2000;
- Governments together with civil society and private sector, to establish a river basin management learning system that stimulates improved understanding of and capacity in management of river basins;
- NGOs, schools and universities to develop training modules and train teachers through the support of government and donors;
- Teachers to train students and trainers on ecosystem functions and benefits based on developed course modules;

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- Teachers and NGOs to develop curricula on freshwater ecosystem management as practiced at the river basin level;
- River basin organisations to cooperate to create a Water Tribunal that is linked to the implementation of the New York Convention (1997), and NGO groups to raise awareness for signing of this convention;
- Convention secretariats, international organisations, governments, lawyers and NGOs to develop synthesised information on (Integrated) Convention Management and their implementation, including handbooks and training courses for private sector groups, teachers and NGOs/CBOs;
- NGOs/CBOs and women's groups to develop materials for awareness and education on conventions;
- NGOs to provide training on conventions' content and implementation;
- River basin organisations, governments, NGOs and donors to develop a clearing house on freshwater ecosystem management at river basin levels that includes, for example, best practices, manuals, guidelines, standards and contacts, and is used to establish exchange of experience and expertise.

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Workshop Report

1. Introduction

This report provides a summary of the discussions and outputs of the Freshwater Ecosystem Management & Environmental Security Workshop held in San José, Costa Rica, June 20-22, 1999. This workshop was convened by IUCN – The World Conservation Union as a part of the Water and Nature (environment and ecosystems) component of the World Water Vision (see Annexes 1 and 2 for description of both processes).

This workshop was the third and final in a series of interlinked workshops which constituted the first phase of the broad-based consultation process which will ultimately lead to the creation of a Vision for Water and Nature. The objective was to examine the specific issue of environmental security in relation to freshwater ecosystem management; the related topics of social security and economic security were addressed at separate workshops.

The workshop brought together 30 professionals with a wide variety of geographical and technical backgrounds and expertise related to environmental security issues associated with freshwater ecosystems and water resources management (participant list in Annex 3).

As a starting point for debate, a draft discussion paper was tabled. In addition to this discussion paper, inputs were sought from all participants prior to the workshop to round out the basis for discussion. All participants were invited to submit 300-word statements on the two or three crucial elements to be addressed by a Vision statement on freshwater ecosystem management and environmental security.

During the workshop, a combination of plenary and smaller working group sessions examining specific topics were used to arrive at the final workshop statement. Additionally, as this is only one part of the overall World Water Vision process, participation from and links to other sectors of the World Water Vision were worked into the proceedings.

At the conclusion, a Final Statement on Freshwater Ecosystems Management and Environmental Security was produced and discussed. This main output of the workshop will feed into the development process for the Vision for Water and Nature as a whole.

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2. Workshop Discussion Report

The workshop aimed to facilitate discussion by adopting a format that combined discussion groups with plenary sessions, in order to maximise the contribution of participants' expertise and their diverse backgrounds. In addition, simultaneous Spanish/English translation was provided to take full advantage of the contributions to be made by the large number of participants attending from Latin America. The agenda was developed to allow a free and critical discussion on the institutional processes affecting freshwater ecosystem management and environmental security. The final agenda can be found in Annex 4.

The Workshop was opened by Mr. Enrique Lahmann, Director of the host organisation, the IUCN Regional Office for Meso-America (ORMA). Dr. Lahmann noted that IUCN has been involved in this region for more than ten years in forests and protected areas, wildlife in wetlands, ICZM, and conservation in general. Whereas elsewhere in the world, water shortage is the main problem, here it is a matter of quality and excess water (floods and related impacts). Regional differences such as these should be kept in mind as we work towards a common global Vision for Water and Nature.

Next, Max Campos, Executive Secretary of the Comité Regional de Recursos Hidraúlicos, Costa Rica, was introduced as the Chair of the workshop. In his introductory comments, Dr Campos noted that his organisation has been concerned with conservation of watersheds and resources since the 1960s. Improvement in management practices is a key thrust. Climate change is a very real threat in this region in regard to water issues (e.g. floods) and this issue should not be lost sight of when developing a global vision that more often is concerned about water shortages. Many parts of the region have suffered severe impacts of this kind already, and there is reason to expect this will be more severe in the future. Nevertheless, the issue of availability of water in Central America must be kept in mind because of the geographic variability within the region. Population growth and demand due to improved economy will lead to additional pressures on freshwater resources. Climate scenarios for Central America for the next 20 years are a cause for concern, projecting a decrease in precipitation by 20 per cent.

The Technical Co-ordinator of the Vision for Water and Nature, Ger Bergkamp, Senior Freshwater Specialist at IUCN headquarters, gave an overview of the Water and Nature consultation process and its relationship to the World Water Vision and the Framework for Action. He emphasised the need to improve the linkages between the communities of interest involved in the environmental aspects of freshwater at the ecosystem level, and to increase the dialogue between them and the other sectors involved in the Vision process.

He reinforced the concept that we are examining Freshwater Ecosystem Management as it relates to the three dimensions of security: social, economic and environmental. Workshops on Social and Economic security have already taken place and the reports (draft in the latter case) were passed out in the package participants received upon arrival. Each workshop provides one building block for the Vision on Water and Nature.

The next steps in the process involve cross-linking with the other sectors. After this workshop, a workshop statement will be published, as has been done for the other workshops. We will then prepare the first draft Vision of Water and Nature for presentation at the Stockholm Water Symposium, along with other Sector and Regional Visions. Then we will go into a second round of consultations leading to a final Vision by next March. The real work really just begins then, with the Framework for Action presented at the same time by the Global Water Partnership (GWP) being the blueprint for direct action to be taken to correct the problems identified in the Vision.

The Regional Coordinator of the workshop, Rocío Córdoba, Wetlands and Coastal Zone coordinator, IUCN-ORMA, explained to the participants the methods of operation for the workshop and the expected outputs. The most important result of the meeting is the development of practical solutions to lead to a sustainable water world through a Vision for Water and Nature. The background document gives us a starting point for what the ideal vision for the future of water could and should be. Through the workshop breakout sessions we examine various local and global challenges that face us in achieving a sustainable water world and in producing environmental security.

The participants in the workshop were each given an opportunity to introduce themselves, to indicate their affiliation, and to state their major objectives in participating. Following these introductions, a brief summary of the Background paper was provided by its authors, Mike Acreman and Matthew McCartney.

It was pointed out that the paper is not meant to be a comprehensive review of the whole subject but rather it concentrates on technical environmental issues as the social and economic issues have already been dealt with extensively in other papers; even so it is inevitable that there will be much overlap because of the interrelationships among social, economic and environmental security.

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To set the stage, the paper provides a concise definition of Environmental Security:

Environmental security is that aspect of human well-being determined by the state of ecosystem resources and functions. The level of environmental security affects the extent to which the social aspirations, economic goals and ethical commitments of both present and future generations can be met.

It goes on to describe the benefits of freshwater ecosystems to humankind because these are so second nature to us that they are often taken for granted and neglected when considering all the factors in water resource management decision-making. The many uses of water are outlined. In summary, human appropriation of water is about 30 per cent of all available fresh water and the trend predicts removing more and more water from nature. In writing the paper, the authors tried to stick to commonly used principles in the literature but assembled them into a pressure-state-response type of model. Driving forces lead to **pressure** on systems, which in turn changes the **state** of the environment, leading to **impacts** which then precipitate a needed **response**. The paper explores the stresses in the real world before examining the three scenarios suggested in the World Water Vision: Conventional Water World, Water Crisis World and Sustainable Water World. Each of these was then applied to the issue and to the concept of ecosystem management. The authors provide a definition of ecosystem management and argue that there are problems with this concept in practical application. They prefer the concept of Integrated Catchment Management and, for the purposes of the workshop, they modified the definition of this concept used in the text to get away from pure water focus and broaden it to embrace the useful elements they find in the ecosystem management concept.

Dr. Acreman went on to explain the benefits (intrinsic and in goods and services afforded) of providing water to natural ecosystems. Similarly, he looked at the benefits derived from providing water to managed ecosystems (e.g. where industry, agriculture and other uses are the focus). But these uses also create impacts which are not there in the natural system. Also, goods and services from natural functions are permanent or very long-lived, while benefits from heavily managed systems may not be sustainable. On a time line, it is often concluded that long-term benefits are greater in a managed system than a natural system. This is a troubling hypothesis that needs closer examination. They argue that you can add the benefits of the natural system to the benefits from a somewhat artificial system under proper management systems. But the more artificial a system has become, the fewer net long-term benefits can be anticipated.

One of the main problems with ecosystem management as an 'ethic' is that everyone believes in it as an ideal concept but in practical terms it may not be workable. To counteract this, some simple basic principles need to be accepted. For the purposes of the workshop these were simplified down to a basic ten commandments of water use, for example:

- Though shalt not waste fresh water
- Though shalt not pollute
- Remember to share fresh water equitably
- Though shalt not reduce biodiversity nor destroy ecosystem functions
- Recognise the indirect values of fresh water and freshwater ecosystems
- Do not keep water secrets
- Use the best multidisciplinary advice available
- Involve all stakeholders in water resource decision-making

etc.

There are problems in applying even these simplistic ethics. Laws created to address these ethics will always make exceptions that appeal to local circumstances and that will not be in the long-term best interests.

A number of impediments to implementing ecosystem management were identified: vagueness of definitions or multiplicity of meanings for the same term; lack of awareness of techniques; lack of long-term foresight; lack of linkages between environmental, economic and social goals; and difficulty in incorporating science in decision-making processes.

Finally a number of issues from the final box in the paper, but converted to statements to provoke comment, were tabled:

- Biodiversity can actually be a constraint rather than a benefit. When can we sacrifice biodiversity? Is this simply a question of social preference?
- Is Environmental Security different from Ethical Security? Should they be treated as separate? When do we have a moral duty to protect other species? Is there a way of valuing ecosystem values?
- Is the concept of ecosystem management too focussed on traditional resource exploitation? Is it true that benefits from artificial systems are sustainable in the long term?
- Are we always forced to make compromises that impact the environment in multi-stakeholder planning?
- Science normally complicates rather than facilitates decision-making. How can we turn this around? What information is truly needed to manage an ecosystem?

Participants provided their preliminary comments on the background paper and sought clarification on a number of points. It was noted that water quality needs to be emphasised as much as quantity in the Vision. In this regard, it was also noted that the scenario presented in the text of the sequencing of pollution problems already faced in the North may not be the same in the South. It was explained that this concept was developed by UNEP and simply borrowed for this presentation. It may or may not prove to be a useful predictive tool. On the subject of whether natural or modified ecosystems are most productive overall and in the long term, the example of the Nile was cited, in which a human-made modification has resulted in an enormous increase in overall production of food. On the other hand, the losses of productivity in the natural ecosystem are seldom put into the balance against these gains.

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Chris Morry and Wolf Krug gave overviews of other two workshops in the Vision for Water and Nature consultation project – Social and Economic Security. It was also stressed that Nature is only one of many sectors in World Water Vision process, the other two main ones being Water for Food and Water for People, but with other elements of water use being studied and introduced into the World Water Vision in parallel by other groups (e.g. the global examination of large dams by the World Commission on Dams).

The two days of group discussions were designed to examine topics from different aspects in order to identify principles, challenges and strategies intended to lead to development of a Vision statement. To introduce the work to be undertaken in breakout sessions, Ger Bergkamp explained the structure of the group workshops:

- Working Group 1 (Jon Kusler, facilitator) – Local Issues – framing the issues, looking at discussion points in the document focussing on the local to national scale.
- Working Group 2 (Enrique Lahmann, facilitator) – Regional to Global Issues – similarly reviewing the issues from this perspective.

Assignments to one or the other of the two working groups were flexible and open to change, so that individuals could offer their assistance where they felt it would be of most value. Facilitators were provided with a set of questions to lead discussion, but by and large the flow of discussion was up to the participants.

Plenary sessions held at the end of the first and second day of the workshop allowed opportunities for the participants in the two breakout groups to review the work of the other group and to share ideas. In this way, the somewhat artificial division between issues of local versus regional and global concern was broached and common ideas emerged where appropriate. The final day plenary was spent in detailed review of the Vision statement, which was revised extensively based upon debate and comments from the floor.

2.1 Group 1. Identify local-national level challenges on freshwater ecosystem management and environmental security

The question put to the group was: What are the principal differences in current freshwater ecosystems status, impacts and threats and how do these relate to environmental security?

Environmental Security

Discussion arose on the issue of environmental security, which was considered by the group in a wider sense, taking into account its importance for providing ethical, social and economic security at local and national levels. Key issues were included within the concept:

Ethical security

- biodiversity
- ecosystem integrity
- religious, spiritual and cultural values

Economic security

- food
- medicines
- building materials
- pollution control
- protection from floods, storms, droughts, desertification

Social security

- traditional lifestyles
- health
- recreation values
- protection from natural hazards

Challenges

At local and national levels, challenges were defined bearing in mind the limited access of people to decision-making processes and the consequences of the constraints they face on a day to day basis. These were discussed from the wide range of viewpoints represented by the participants and stressing the need to harmonise criteria between the main stakeholders within these stakeholder groups. Several types of challenges were identified, as shown below:

Financial

- lack of money
- effective use of funds

Education/awareness

- to explain ecosystem concepts to local people
- to explain local needs and perspectives to decision-makers
- educating people that water has an ecological and economic value

Information/knowledge

- to popularise science for local people
- to reflect and respect different points of view, local traditions and perspectives
- to exchange information between interested groups and institutions

Participation/empowerment

- to integrate different disciplines in water management (horizontal integration)
- to integrate woman and youths into water allocation and development processes
- to identify key actors at various levels and bring them together
- to develop participatory mechanisms to gain information and to provide local input to decision-making
- to achieve consensus

Planning/politics

- to finding enough space for people and nature where little land is available
- to meet both nature's and peoples' needs and rights
- to overcome the fact that water does not recognize political and cultural boundaries
- to overcome global pressures on resources which are difficult to resist locally

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Science/technology

- to protect functions where there is high environmental variability
- to understand links between loss of function and loss of human benefits
- to identify strategies for both reducing losses from natural hazards and protecting functions
- to reduce natural hazards and dangers while protecting natural function
- to define water needs of particular species and ecosystems
- to determine types of natural function existing in a specific ecosystem, and the levels of functions
- to produce rapid, inexpensive methods for functional assessment
- to define levels of loss of natural functions and what they mean in a specific context

Drivers

Examining the background paper for the workshop, the group defined the key local-level drivers causing freshwater ecosystems degradation, as well as the pressures and impacts, both immediate and in the long term. The major results are shown in the table below.

Table 1 Summary of Drivers, Pressures and Impacts identified by Working Group 1

Driving force	Pressures	Impacts
Population increase, urbanisation	Construction of reservoirs	Loss of flood flows Shift to warm water species Sediment reduction and erosion
Increasing demand for water	Groundwater pumping	Lowered groundwater water levels, loss of wetlands, aquifer compaction, saltwater intrusion
Natural hazards (e.g. floods)	Construction of embankments, drainage ditches, channelisation	Loss of habitat for wetland species
Increasing consumption of goods	Agricultural intensification, application of fertilisers and pesticides	Pollution
	Deforestation for agricultural land, increased use of water and land, increased waste	Destruction of natural habitats and species
Globalisation of trade, expectations and demands	Rice production, aquaculture	Pollution, diseases
Landlessness, inequality, poverty	Building/living in dangerous places	Health risks
Wars, regional aid, political repression	Demographic changes	Pollution, loss of species
Burning fossil fuel, use of CFCs	Climate change	Loss of species, migration of species, more extreme events
	Rising sea levels	Salinisation of coastal aquifers
Natural climate variability	Extreme events (floods, earthquakes, hurricanes)	Loss of species, wetlands destruction
	Successional sequences, stream meanders, beach erosion	Extinction of species
Spatial mismatch between people and resources	Water diversions	Introduction of exotics, loss of species
Lack of awareness or ethic, or loss of identity with land, water, sense of place	Mismanagement of water and land	Loss of species
Poor legislation		
Incomplete economic management	Poor use of resources	

* there is an interconnection of driving forces, pressures and impacts through feedbacks
** fragility of ecosystems can result in more severe impacts

Information Gaps

The group discussed the major gaps in awareness, knowledge, policies and capacities related to freshwater ecosystem management that need to be addressed at local and national levels. It was decided to analyse mainly the information gaps producing the following results:

- data on hydrological cycle (in general and site specific;)
- value of ecosystem functions and species;
- cost of hazards, loss of life, health problems and environmental security;
- critical water needs and interactions for species and ecosystems;
- reflecting different cultural perspectives;
- how equity is to be achieved in allocation of water between different economic and cultural groups;
- dissemination, communication and use of information.

2.2 Group 2. Identify regional-global issues related to freshwater ecosystem management and environmental security

Working Group 2 was asked to identify the regional to global issues related to environmental security and freshwater ecosystems management that should be addressed by the global and regional approaches to be defined later:

What are the principal differences in current freshwater ecosystems' status, impacts and threats, and how do these relate to environmental security?

The working group started by examining two key questions:

1. Are the differences in environmental threats and impacts between North and South (i.e. developed and developing countries) significant?

- No: many threats/impacts are the same
- Yes: some impacts are different or more critical (food security, per capita consumption, disease prevalence)

2. Will technical fixes work in developing countries?

- Yes: some problems are the same so the same solutions should work
- No: developing countries lack resources, capacity and governance to make them work

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This in turn led to agreement on two major issues:

- the South should not blindly follow models suggested by the experiences of the North
- empowerment of South is up to the South as well as the North

As a means of exploring this further, two examples of attempts at managing transboundary issues, one in the North (the Canada/US International Joint Commission [IJC] on transboundary waters) and one in the South (Southern African Development Council [SADC]), were compared and contrasted to one another:

Table 2 Comparison between developed and developing country international institutions

Developed (e.g. IJC)	Developing (e.g. SADC)
Mature venture	New venture
Developed governance	New governance
Enough information for management	Lack of management information
Plenty of resources	Too few resources
Plenty of capacity	Lack of capacity
Institutions well-developed	Institutions poorly-developed
Difficult decisions aren't discussed	
Lack of political will to enforce global conventions	
National interests come first	

Despite these differences, it was concluded that there are several commonalities in goals and principles that are universal:

Goal

- Manage freshwater ecosystems to maximise security

Principles

- economic (willingness to pay, fair costing, optimising benefits)
- social/equity (equitable distribution)
- technology (appropriate and locally adapted)
- legal (adhere to conventions)
- information (equal and open access, empowerment)
- conservation (protect biodiversity/ecosystem functions)

It was also concluded that we need to remember where we are coming from in a Vision exercise such as this. Much of what we are attempting to define in the Vision has been stated before. A case in point is the Dublin Principles, which bear remembering:

The Dublin Principles

- fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment
- water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels
- women play a central part in the provision, management and safeguarding of water
- water has an economic value in all its competing uses and should be recognised as an economic good

2.3 Group 3. Defining strategies that will lead to improved freshwater ecosystem management and environmental security at a local to national level

The aim of Group 3 was to identify strategies at a local level that are needed to achieve environmental security. The group first identified the key stakeholders in making decisions about water and ecosystem management, and then proposed specific actions that each should take to improve the decision-making process. Finally, the mechanisms through which the desired action could take place were also identified.

The results of discussion are summarised in Table 3. The group acknowledged that it did not adhere strictly to its mandate, in that many of the actors and actions are applicable at a regional to international level.

Principles

After this table was re-examined, it was decided to extract some general, cross-cutting principles and identify strategies for each. The nine principles and associated strategies are summarized as follows:

1. Institutions

- creating or strengthening of water basin authorities to coordinate stakeholders
- forum for participation of stakeholders/public hearings, particularly environmental organizations at early stage
- mandate of river basin authorities/government agencies to include baseline data (hydrological, sociological and biological)
- independence of river basin authorities

2. Economics

- economic instruments to ensure sustainable use of natural resources/ecological accounting
- environmental accounting and pricing
- effective and targeted investment
- monitoring of investment
- environmental guidelines to be eligible for funding

3. Equitability

- equal role to all stakeholders, but they must all accept responsibility
- equal opportunity for all current and future generations
- priority to meeting basic needs
- equitable allocation/use of water resources

4. Information sharing

- inventories, maps, joint information gathering
- baseline data must be collected
- dissemination to all
- use and respect of indigenous and local knowledge
- popularization of scientific results/put technical jargon into laypeople's terms

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Table 3 Summary of Working Group 3 Discussions: The 'Who, What and How'

	Internal Actions (taken individually, independent of established decision-making processes)		External Interactions (involvement in established decision-making processes)	
Actors	**Desired action**	**Mechanisms**	**Desired action**	**Mechanism**
Civil Society	Appreciate value of water; demand more accountability of decision-makers and more targeted plans	Pricing, minimum cost; education; legal requirement for civil claims/inputs	More participation; empowerment; take more responsibility	Education; schools, plays/radio; information sharing; legal framework changes; commitment to act with those involved
Youth	Create new ideas	Involvement in debates	Be involved	
Engineers/ Technical Experts	Appreciate ecosystem processes; work with ecologists and others; appreciate technical engineering issues; develop decision-support tools	Training; provision of case studies; form interdisciplinary teams	Improve communication	Broader curricula; development of guidelines
Private Sector	Longer-term vision; (profit-driven too often)	Economic incentives; sustainability; green accounting; polluter/user-pays principles; green fund; tax incentives for green company shares; international trade agreements; sustainable farming		Shareholders should encourage green approach
NGOs			Effective bridge between different actors (political, private)	Recognition of role
Government Depts	More effective use of limited funds; more notice of role of women; less corruption; more sustainable land-use planning/ multifunctional use of green space; facilitate creation of river basin councils; recognition of minority groups	Green accounting; public evaluation; provide tools for planning; create legislation to create/ strengthen river basin councils where lacking; legislation to include minority groups		
Scientists/ Investigators	Develop better methods for ecosystem function assessment, water needs of ecosystems, methods of reducing natural disaster impacts	Provision of research funding	Disseminate scientific results to everyone	Earmark research funds for dissemination
Women	Need higher appreciation of sustainability; conservation of environment	Targeted education	Participate	50/50 (men/women) quota; targeted education
Development Banks	Include environment in development options	Stronger regulations (EIAs, green accounting)	Target real problems	Consultation with local people at conception of projects; global vision development
Politicians	Longer-term vision	Accountability; education	Bridge between different actors	Accountability (democratic)
Judges	Act against environmental degradation; punishment fit the crime	Stronger environmental legislation; training of judges in environmental issues		
River Basin Councils	Develop and implement river basin management plans; baseline data	Legislation to collect data; empowerment of councils; sufficient resources	Include stakeholders	River basin action plan; exchange of experience between river basin councils

Note that the blanks in this table do not mean to imply that no action is required; this table was left partially incomplete due to time constraints.

5. Legislation

- harmonisation of legislation of different sectors relating to water use, pollution, application of pesticides, mining, etc.
- updating of legislation to implement new concepts and principles
- environmental guidelines to be eligible for funding

6. Technology

- development of strategies for mitigating against natural disaster impacts
- systematic collection of ecological data, hydrological and sociological data i.e. through networks of monitoring sites
- application of technology appropriate to local conditions
- development of environmentally-sound technologies (to reduce pressures on water resources)
- development of methods to determine water needs of ecosystems
- development of methods for assessing ecosystem functions

7. Conservation

- conservation of ecosystems functions
- implementation of integrated river basin management/ecosystem management
- 'no net loss of ecosystem functions'
- priority given to rare /strategic/unique ecosystems
- implementation of 'wise use' of ecosystems (along the lines of the Ramsar Convention)
- recognition of characteristics and resource use pressures of different river basins

8. Participation/empowerment

- horizontal participation (multidisciplinary: hydrology, ecology, sociology)
- vertical participation (stakeholders e.g. public, women, NGOs, indigenous groups)

9. Resource use

- change attitudes to water use – demand management
- sense of identity and responsibility for water use
- solidarity with other users
- strategies for coping with variability and vulnerability

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2.4 Group 4. Defining strategies that will lead to improved freshwater ecosystem management and environmental security at regional to global levels

The group felt strongly that a strategy must be rooted in basic and agreed principles. Therefore, a considerable amount of time was dedicated to the definition of the principles that need to be considered in a number of key areas (note that the bullets are only given as examples; many other issues were considered):

Principles

Economic

- economic alternatives must be provided to discourage unsustainable practices
- consistent implementation of economic instruments (polluter pays,...) is essential
- application of green accounting is an important part of strengthening regional financial mechanisms

Social

- equitable sharing and full stakeholder involvement are essential
- strategies must lead to empowerment of women, who play so many unrecognised roles with regard to water resources

Technology

- promote new technology (especially low-cost alternatives)
- technologies advocated for use in the South should be affordable and adapted to local use by local users

Legal

- develop, ratify and implement laws and conventions
- monitor and enforce laws and conventions
- harmonise legislation (national laws and international conventions)

Information

- involve multidisciplinary expertise early on
- develop data bases (locally, regionally, globally)
- develop cost-effective information tools and provide equal access to these
- develop learning systems

Conservation

- abide by precautionary principle/wise use
- implement periodic resource audits and State of Environment reporting

Cooperation

- provide incentives for regional and international cooperation
- promote cooperation between and within sectors/regions/nations
- build regional capacity and institutions

Integration

- link social, economic and environmental goals

Strategies

With these same basic principles in mind, it was nevertheless determined that, in many cases, different strategies are required at the regional and global scales:

Regional strategies

- river basin management
- networks
- others (learning mechanisms; regional cooperation for environmental security)

Global strategies

- conventions/agreements/accords
- ethics

For each of these strategies it is necessary to define who should take responsibility or participate, what function or functions each of these players should undertake, and how they should accomplish these functions. In many cases, the 'what' and the 'how' are synonymous, or the 'how' is self-evident, thus the tables that follow do not always include the latter.

A special case emerges in discussing the ethical dimension. Ethical responsibility for maintenance of freshwater ecosystem integrity is everyone's responsibility and the classic approach used in the tables above therefore is not applicable. A number of points emerged in the discussion of ethics:

Ethical Dimension

- definition: Moral responsibility to protect the environment.
- sometimes conflicts with ethical responsibility to feed all of humankind.
- we can promote the ethical dimension by working through religious organisations that support this ethic and through schools that build this ethic in children.
- we can use the power of visual imagery to persuade (e.g. see images of landlocked boats in Aral Sea, the fragile blue planet seen from space, etc.).

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Table 4 Strategies for River Basin Management

Who	What	How
Government/State	Formalise IRBM agreements Formulate and implement policy Monitor water quality/quantity and freshwater ecosystems (incl. coastal zone)	Participatory approach Provide needed staff and resources
River Basin Organisations	Implement the IRBM agreements	
NGOs/CBOs	Information and awareness Advocacy for consensus	Campaigns, publications, outreach, training
Lawyers	Draft and harmonise laws Case studies of best-law practices	Use multinational and multidisciplinary teams Binational, regional and international agreements
Researchers	Gather, analyse, synthesise and disseminate information on ecosystem functions Monitor and report on ecosystems	Apply scientific methods Pilot projects and basin-wide studies Publications (scientific and popular)
Private Sector	Abide by regulations Manage water supply services Act as good corporate citizens Carry out EIA	Act responsibly Abide by the law Training
Donors and Financial Institutions	Provide financing for capacity-building and infrastructure Pay incremental costs	Contribute, initiate and respond Support the implementation of agreements Fund basin research
Teachers	Educate on ecosystem functions/benefits and water Raise awareness	Develop course modules and curricula Be trained
Gender (Men and Women)	Recognise the role of women in IRBM	

Table 5 Strategies for Network Creation

Who	What	How
Government/State	Initiate and support the development of networks Help resolve disputes Develop regional economic instruments/incentives	
River Basin Organisations	Share experiences and best practices Cooperate to create a tribunal	Clearing houses Manuals
International Organisations	Develop inter-sectoral consensus on integrated river basin management	
NGOs/CBOs	Political pressure to comply Campaign for NY 1997 signing	
Lawyers	Harmonise laws Raise awareness on NY 1997 Conv	
NB: need both horizontal (within group) and vertical (between group) networks		
Researchers	Build consistent approaches Publish results Develop and adapt appropriate technology	
Private Sector	Sponsor TV programmes on research capacity	
Donors and Financial Institutions	Harmonise aid programmes Co-finance major projects	
Teachers/Universities	Capacity-building exchanges Joint curricula	CAPNET, WATERNET, etc.
Gender (Men and Women)	Women's networks to raise the profile/role of women in IRBM	

Table 6 Strategies for Conventions

Who	What
Government	Establish water tribunals
International Organisations	Pressure governments to implement conventions Develop integrated convention tables to identify overlap and compliance/violation of various conventions
NGOs/CBOs	Pressure governments to implement conventions Training of trainers on conventions
Lawyers	Draft conventions Training of trainers on conventions Handbooks for private sector on convention
Researchers	Develop and implement technologies to facilitate capacity to implement conventions Advise governments by providing ecosystem information relevant to compliance
Private Sector	Develop and implement technologies to facilitate capacity to implement
Donors and Financial Institutions	Financial assistance to support enforcement
Teachers/Universities	Use materials available to educate and raise awareness of conventions

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3. Conclusions and Next Steps

The key output from the Workshop was the Vision statement, repeated before the introduction to the present report. A draft of this statement was developed during the final session of the workshop. It was then reworked and submitted to participants for feedback following the workshop. The version contained herein is therefore considered final.

This Final Statement is not meant to be considered as a stand-alone document. Rather, this Vision forms one input into the development of an overall Vision for Water and Nature. It will be combined with similar Visions on social and economic security already developed through earlier workshops. This having been said, comments are always invited on any contributing element to the Vision for Water and Nature, including this Environmental Security Vision statement, to validate its conclusions and to ensure that it has encompassed all relevant issues.

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Annex 1

World Water Vision

Throughout 1999 until March 2000, the World Water Council is developing a **Vision for Water, Life and the Environment in the 21st Century (World Water Vision)** to address the pressing issue of scarcity of freshwater in localised areas, and chart a course toward more sustainable and equitable use of water resources.

It is intended as an intensive consultation exercise, bringing together stakeholders and professionals, both within and outside the water sector, which is meant to take us from where we are today to where we need to be to meet future water needs. This process of study, consultation and promotion aims to:

- *develop knowledge* on what is happening in the water sector, and on trends and developments outside the water sector that will have an impact on future water demand and supply;
- *raise awareness* of water issues among the general population and decision-makers in order to foster the political will and leadership necessary to achieve the Vision;
- *produce a consensus* on a Vision for the year 2025 that is shared by all stakeholders;
- *contribute to a framework for action* with steps to go from vision to action.

The consultations will take place through a number of means:

- *Thematic Panels*: experts consider possible future developments in biotechnology, energy technology, information technology and institutional changes, and their implications for the water sector.
- *Scenarios*: a framework that describes possible futures and their driving forces.
- *Sectors*: professionals discuss strategic water issues in key sectors: Water for Food, Water and Nature, Water for People (supply and sanitation), and others.
- *Regions*: regional stakeholders will discuss and develop a regional vision: a desirable future and how to get there.

In addition, a website has been developed to facilitate broad-based consultations from all interested parties: http://www.watervision.org

Annex 2

Vision for Water and Nature

IUCN-The World Conservation Union has been asked to lead the development of a specific sector vision on **Ecosystems and the Environment (Water and Nature)**. This Vision for Water and Nature will be combined with and contribute to visions of the other sectors, as well as the regional visions addressing the geographically varying issues confronting different parts of the world.

To develop the Vision for Water and Nature, IUCN will call upon the advice of many specialists and interested organisations, not only in the water sector, but in different socio-economic and scientific disciplines that bear upon the use of water.

The key basis for consultations will be three workshops, focussing on the related themes of how management of freshwater and aquatic ecosystems affects **social**, **economic** and **environmental** security. At each workshop, participants will examine, as a starting point for debate, expert opinions captured in discussion papers which are intended to challenge conventional thinking. At the same time, all interested individuals will be invited to examine and offer their comments on these documents via Internet-based discussions. The three scheduled workshops are:

- Freshwater Ecosystem Management & Social Security, April 13-15, 1999, Harare, Zimbabwe
- Freshwater Ecosystem Management & Economic Security, June 9-11, Bangkok, Thailand
- Freshwater Ecosystem Management & Environmental Security, June 20-22, 1999, San José, Costa Rica

The draft Vision for Water and Nature will be submitted at the Stockholm Water Symposium in August 1999 and provision will be made, if required, for a final round of consultations to complete the Sector Vision. It will then be incorporated into the final product of the overall process: an integrated World Water Vision for the 21st century, to be tabled at the 2nd World Water Forum and associated ministerial conference in The Hague in March 2000.

A website has been launched to provide information specifically on the Water and Nature process, post key documents such as the discussion papers and workshop reports for downloading, and provide a forum for input into the consultations (http://www.waterandnature.org)

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Annex 3

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Annex 4

Freshwater Ecosystem Management & Environmental Security Workshop Agenda

San José, Costa Rica, June 20-22, 1999

Day 1	Sunday, 20 June, 1999
8:30-10:00	**Opening session** Welcome – Enrique Lahmann (IUCN Regional Director) Opening remarks – Max Campos (Chair) Overview on Vision for Water and Nature – Ger Bergkamp Presentation of participants and expected outputs of the meeting – Rocio Cordoba
10:00-10:30	*Coffee Break*
10:30-12:00	**Discussion of the Background Document** The Freshwater Ecosystems Management and Environmental Security discussion paper – Mike Acreman
12:00-12:45	**Background on the Vision work** Social Security workshop output Economic Security workshop output The World Water Vision – Water for Food component The World Water Vision – Water for People component
12:45-13:00	**Framework for discussion groups** – Chair
13:00-14:00	*Lunch*
14:00-15:30	**Discussion Groups – Framing the issue** • Group 1. Identify local-national level challenges to freshwater ecosystem management and environmental security • Group 2. Identify regional-global issues related to freshwater ecosystem management and environmental security
15:30-16:00	*Coffee Break*
16:00-18:00	**Discussion Groups – Framing the issue** (continued) • Group 1. Identify local-national level challenges on freshwater ecosystem management and environmental security • Group 2. Identify regional-global issues related to freshwater ecosystem management and environmental security

Day 2	Monday, 21 June, 1999
8:30-9:45	**Reporting on Day 1 discussions** Presentations of working group outcomes Reactions from the floor
9:45-10:00	**Framework for discussion groups** – Chair
10:00-10:30	*Coffee Break*
10:30-12:30	**Discussion Groups – Exploring management strategies** Framework for discussion groups – Chair • Group 3. Defining strategies that will lead to improved freshwater ecosystem management and environmental security at local to national levels • Group 4. Defining strategies that will lead to improved freshwater ecosystem management and environmental security at regional to global levels
12:30-14:00	*Lunch*
14:00-15:30	**Discussion Groups – Exploring actions required** (continued) • Group 3. Defining strategies that will lead to improved freshwater ecosystem management and environmental security at local to national levels • Group 4. Defining strategies that will lead to improved freshwater ecosystem management and environmental security at regional to global levels
15:30-16:00	*Coffee Break*
16:00-17:30	**Proposing solutions – Plenary session** Report of group discussions Reactions from the floor
17:30-18:00	**Defining a Draft Framework for the Final Statement**
18:30-21:00	**Evening drafting group produces a draft statement**

Day 3	Tuesday, 22 June, 1999
8:30-9:15	**Circulation of the workshop reports (drafts) and reactions**
9:15-9:45	**Presentation of the draft statement**
9:45-10:15	*Coffee Break*
10:15-12:30	**Discussion of the draft statement**
12:30-13:30	*Lunch (small group redrafting of the statement based on discussion)*
13:30-14:30	**Finalising the redrafted statement**
14:30-14:45	**Closing Plenary**
14:45-15:30	*Closing Coffee Break*

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ISBN: 2831705789

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Cover photos: FAO,
D. Minty (lower)

Graphic design:
Langevin et Turcotte

Photo-retouch:
Kaboom production
infographique

Printing: Les productions
graphiques J7

Produced by:
IUCN Vision for Water
and Nature team

Printed on:
Artica 40M, Provincial Papers,
Jenson Satin, cover 200M

Printed in Canada

Printed on recycled paper

Copies of the *Vision for Water and Nature* available in English, French and Spanish

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Available from:
IUCN Publications
Services Unit
219c Huntingdon Road
Cambridge
CB3 ODL
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