IUCN-WESCANA
Water Publication

The Conservation and Sustainable Use of Freshwater Resources in West Asia, Central Asia and North Africa

The 3rd IUCN World Conservation Congress

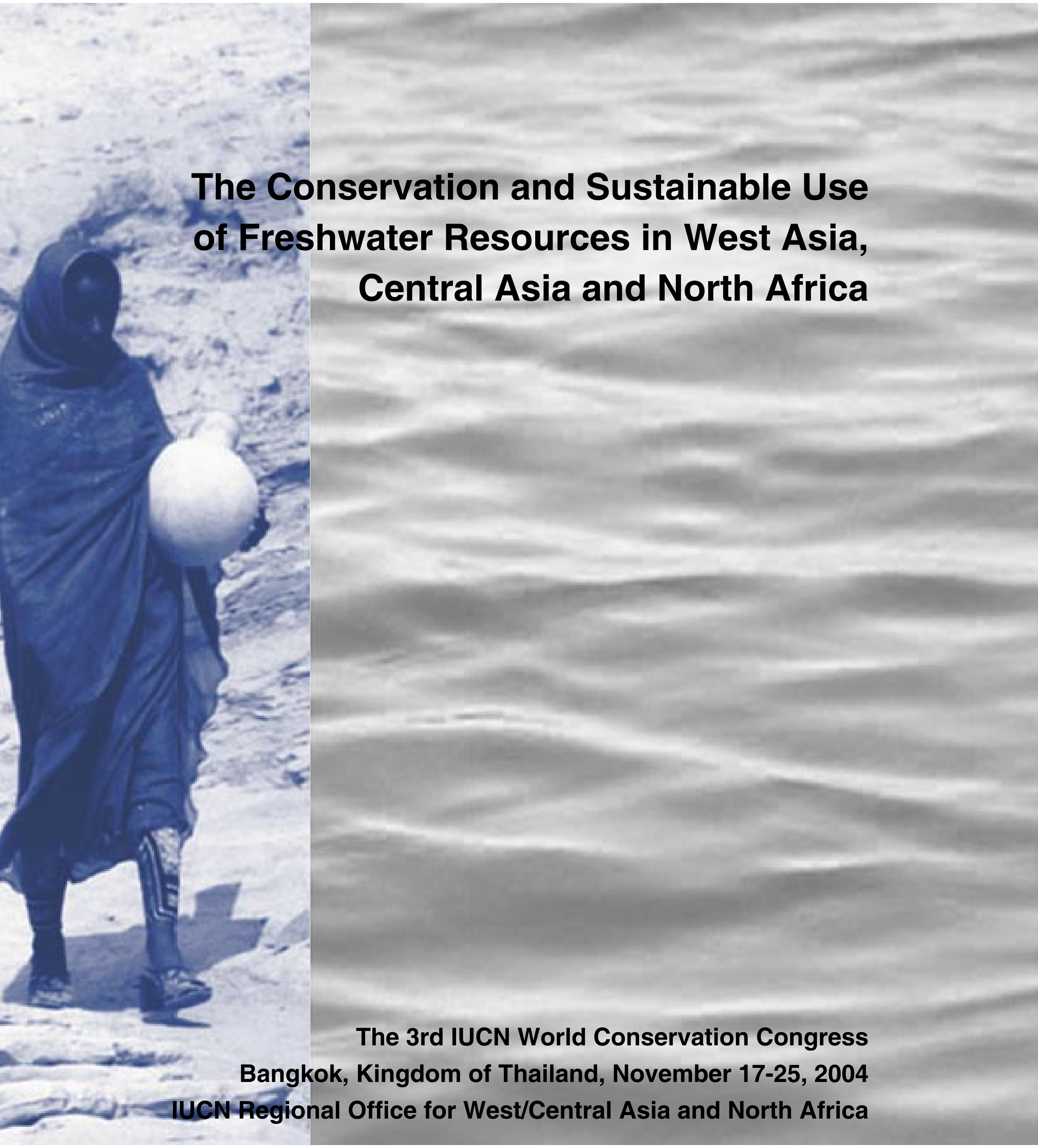
Bangkok, Kingdom of Thailand, November 17-25, 2004

IUCN Regional Office for West/Central Asia and North Africa

Kuwait Foundation For The Advancement of Sciences

Cooperazione Italiana

IUCN
The World Conservation Union



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Summary

The IUCN-WESCANA Water Publication – The Conservation and Sustainable Use Of Freshwater Resources in West Asia, Central Asia and North Africa - is the first publication of the IUCN-WESCANA Office, Amman-Jordan. It is to be launched during the World Conservation Congress (WCC) in Bangkok, November 17-25, 2005. The rationale of the IUCN-WESCANA Water Publication is to contribute and share knowledge about conservation and water management.

This rationale is in line with the IUCN Framework for Action as outlined in the Vision for Water and Nature. This framework proposes six goals to achieve sustainable water management. Specifically, 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.

This IUCN-WESCANA Water Publication sought to bring into focus some of the many issues related to the conservation and sustainable use of freshwater resources across the WESCANA region. This publication includes 6 technical papers prepared by specialists representing each of WESCANA's four sub-regions (the Arabian Peninsula, Mid-west Asia, North Africa and Central Asia). The papers addressed water issues from the viewpoint of the four themes of the World Conservation Congress:

- Ecosystem Management: Bridging sustainability and productivity
- Health, Poverty and Conservation: Responding to the challenge of human well being
- Biodiversity Loss and Species Extinction: Managing risk in a changing world
- Markets, Business and Environment: Strengthening corporate social responsibility, law and policy.

Specifically, the first paper by Niazi analyzed the main stakeholders contributing to biodiversity conservation of wetlands in Iran. He assessed the demand of indigenous people for the freshwater resources and their role in preservation and conservation of the wetland ecosystem.

Majeed reviewed economic or market based instruments in conservation. He argued that these instruments affect the relative prices (costs and benefits) of alternative actions, creating markets for natural resources and the environment, these instruments can signal true resource scarcities to users creating economic incentives for wiser management.

Rais addressed the question of carrying capacity and sustainable fishing. The basic question he addressed is: Can the living resources of the inland waters in North Africa be exploited in a sustainable manner? The paper concluded by identifying the constraints on sustainable management of ecosystems. Special reference was paid to the risk of the introduction of invasive species.

Addressing the issues in Central Asia, Dukhovny *et al*. showed the linkages between environment and socio-economic aspects. They documented the root causes and effects of environmental deterioration in the Aral Sea. Moreover, Elena *et al*. documented the extent of biodiversity loss in the Aral Sea Basin due to man-made developments.

Finally, Al-Jayyousi argued that the WESCANA region represents a critical mass and a logical unit of analysis for water assessment and management. Complementarities among nation-states in water, food, and trade represent comparative advantages for each nation-state. Ecological and political borders rarely coincide. Few serious environmental problems can be solved within the framework of the nation state. The fact that regional management programs exist and persist, in spite of nationalist rivalries, shows the imperative need for environmental cooperation. To achieve sustainable water management within a river basin, there is a need for a linkage between international law principles and hydrological considerations.

The demand for Freshwater Resources and the Role of Indigenous People in the Conservation of Wetland Biodiversity

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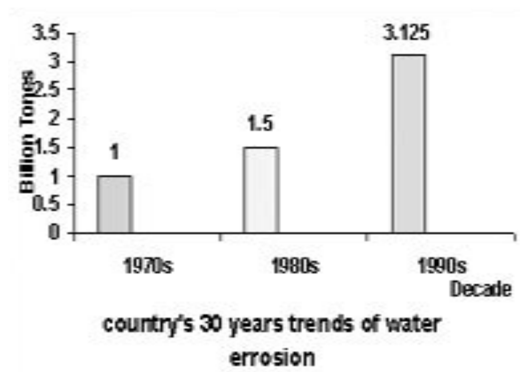
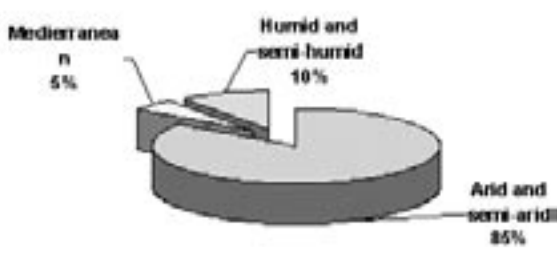
Iran is one of the largest[1] and most populous[2] countries of the Middle East. It is located geographically in the arid and semiarid part of the region where competing demands on particularly scarce and valuable water resources is an important issue[3]. With an average annual precipitation of about 250 mm, which is one third of the world average precipitation, the country suffers in most parts from shortage of freshwater.

Arid and semiarid regions of the interior and far south, which are characterized by long, warm, dry periods, sometimes last over seven months and cover 85% of the country. Overwhelming arid ecosystems, together with over-utilization of ground- and surface-water resources and with increasing trends of erosion within the catchments, have made the situation regarding the demand for freshwater resources much more drastic during the past three decades. Therefore, water and water resources management has been seen as one of the major concerns of the government and the local water users throughout history, and have been considered a top priority of the country's development and conservation policy framework. On the other hand, because of its large size and varied ecosystems, Iran is one of the most important countries in Western Asia in terms of biodiversity conservation. Though a dry country where water resources are scarce and much sought after, Iran has a great diversity of wetlands. Of 286 wetlands currently identified in the country, 86 meet the Ramsar criteria for international importance and 22 have been designated as wetlands of international importance. Seven wetlands also fall under the Montroux classification. Several other wetlands also are located in cross-boundary situations, thus requiring international cooperation for their conservation. A large number of species dependent on wetlands and identified by IUCN as globally threatened, inhabit Iran's wetlands (Department of Environment, 2000).

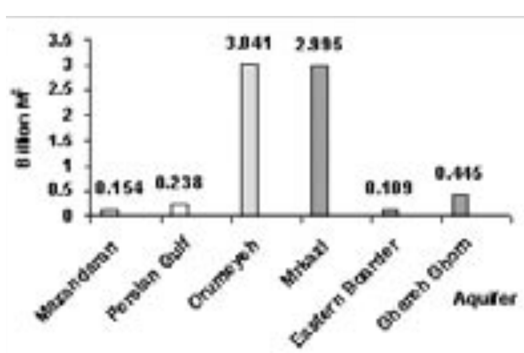


country's 30 years trends of water errosion

These freshwater resources, particularly the wetlands or aquatic ecosystems of ecological importance, are also characterized by their economic values as well as the benefits they can provide for the adjacent communities. At the regional and local level, these values are mainly ecological (landscapes, resources for recreation, habitats for fauna especially for migratory bird species, flood control, etc.) as well as socio-economic (supply



Main climatic zones (percentage of the country)



Overuse of the main aquifers

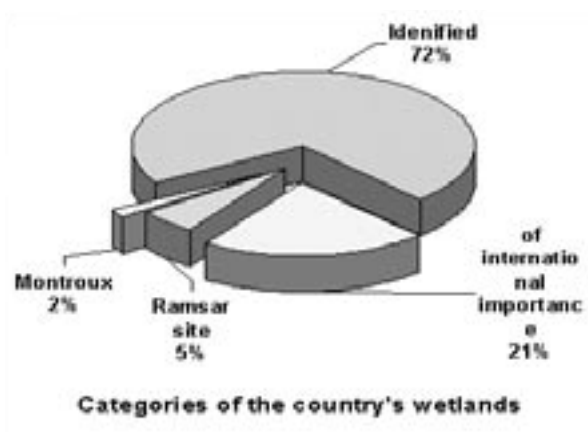
[1] Total area is 1,168,1 59sq. Km.
[2] According to the 2001 census, Iran had a population of 68 million people.
[3] 60% of the area is classified as desert or semi-desert.

of freshwater for urban, sanitary, and agricultural uses, provision of local people needs and amenity, etc.). Thus, conservation of freshwater resources, which is defined as the preservation of the important values of these resources as well as the sustaining of the productivity of the aquatic ecosystems, requires application of a specific management approach that is referred to in this research as “freshwater biodiversity conservation”.

One of the major concerns in wetland conservation is the issue of how to identify the demand of stakeholders for wetland resources and to ensure the continuity of wetland ecosystem’s goods and services. For the purpose of the study, the Fereydoon Kenar wetland (Ramsar Site), together with its adjacent local community settlements, is selected as the study area.

Objectives

A study of the market vs. traditional approaches to freshwater resources conservation with respect to the above-mentioned aspects is the main subject of this research. The study aims to determine and analyze the main stakeholders contributing to biodiversity conservation of the Fereydoon Kenar wetland. In addition the study aims to assess the demand of indigenous people for the freshwater resources and their role in preservation and conservation of the wetland ecosystem. The study particularly focuses on the role of local people, who were considered the main stakeholders and landowners, along with the role of governmental institutions and their approach to wise use of natural resources being supplied by the wetland. A potential for a tourism market development is addressed as an opportunity to base the future conservation policies on. The following main questions are considered for further exploration in this study:



- What are the main values/benefits of the wetland under study (supply side)?
- Who are the main beneficiaries of the wetland resources (demand side)?
- What are the costs of wetland degradation/social costs?
- Who are the stakeholders and what role do they play in wetland conservation?
- Who pays for the costs, do beneficiaries pay for the costs?
- Is there any potential for a market to be developed?
- Are traditional approaches viable alternatives to market-based approaches to an efficient and effective allocation of resources and distribution of costs and benefits?
- What are the main areas of conflict between the market and traditional approaches?
- What are the opportunities to reconcile the market with traditional approaches?

Methodology

The methodology applied to the study basically is based on a cost benefit analysis. Evaluation and assessment of factors contributing to freshwater biodiversity conservation are made through a status quo “principal component analysis” (PCA). At the first step after the main values of the wetland under study are identified, the major contributing stakeholders are specified. The next step is to analyze the demand for natural resources of the wetland by the local communities with respect to the capacity of wetlands to supply resources needed for sustaining the security of the whole ecosystem including the adjacent settlement areas. An evaluation was made to identify and prioritize the significance of the role of local stakeholders and their self-incentives to conserve the freshwater biodiversity. The results of a previously conducted study are used as the basis for economic analysis of the potential costs and benefits. Finally, an integrative approach comprising two components; tourism market development and community-based management for conservation of the wetland is put forward as an opportunity for further consideration.

The study area

The Convention on Wetlands came into force in the Islamic Republic of Iran on 21 December 1975. The Islamic Republic of Iran presently has 22 sites designated as Wetlands of International Importance, with a surface area of 1,481,147 ha (Ramsar Site 2004).

The study area covers all the areas known as Fereydoon Kenar, Ezbaran & Sorkh Ruds Ab-Bandans Non-Shooting Area, BirdLife IBA “Important Bird Area” and Wildlife Refuge.

The area, that was designated on 28 March 2003 as Ramsar Site, has an area of about 5,427 ha, and is located in the Mazandaran province at latitude 36°40'N and longitude 52°33'E near the southern Caspian seacoast. It is an artificially maintained wetland in the South Caspian lowlands.

Existing natural conditions

As described by Ramsar's Liazzat Rabbiosi from the wetland falls under the category of artificially maintained wetlands comprising agricultural irrigated lands, flood plains, and ponds (Lepours). The wetland is located in a moderate semi-humid climate with an average annual temperature of about 18.4 ^{0}C. The average annual precipitation in the region is recorded at 828.7 mm. The wetland is a suitable habitat for a diversity of terrestrial and aquatic fauna. About 11.5% of the country's bird species have been identified in the wetland. It comprises four "damgahs", i.e. shallow freshwater impoundment based on rice paddies developed as duck-trapping areas, surrounded by forest strips and reed-beds. Based on the aerial photographs of the study area, the number of damgahs decreased 40 years ago, but their structure and ecological conditions remained constant. The area is of outstanding importance as wintering grounds for the entire western population of the Siberian Crane (Grus leucogeranus), and is listed as "critically endangered" in the IUCN Red Book. Having appeared at the site in 1978 after 60 years of absence, the number of Siberian Cranes at present fluctuates between 7 and 14. Other endangered species using the site include Red-breasted Goose (Branta ruficollis), Lesser White-fronted Goose (Anser erythropus), Dalmatian Pelican (Pelecanus crispus), and occasionally Pygmy Cormorant (Phalacrocorax pygmaeus) as well as wintering raptors such as (Falco sp.) and (Haliaeetus albicilla) (Sauey, 1987). Previous studies in this area have mainly focused on population dynamics of the cranes and annual bird counts (Vuasalo-Tavakoli, 1991). According to these studies, the population of the Siberian Cranes has decreased from about 13 to 6 (2000/2001) in about 20 years (Ohasako, 1994; Maine & Archibald, 1996).

Wetland values

Three categories of resource values have been recognized in Fereydoon Kenar wetland as follows:

- Ecological values. The wetland acts as a reservoir for biodiversity. It provides a wintering ground for the entire western population of the Siberian Crane and other endangered species (Sauey, 1985). Water purification is another ecological functioning of the wetland. The wetland naturally plays an important role in purification and treatment of pollution. Also the plain areas of the wetland have a role in flood control. Groundwater replenishment, sedimentation and nutrients retention and export, and microclimatic effects are other benefits of the wetland.
- Economic values. The wetland provides the indigenous community with suitable land and water resources for rice farming. Also trappers and hunters benefit from the meat supply of the wetland (even when hunting and trapping are practiced illegally). Local people harvest reeds for their domestic uses, such as for fencing and construction of houses and other facilities.
- Recreation, education/research, and aesthetic appreciation. The area has a good potentially for recreation and tourism. Each year significant numbers of tourists (domestic and exotic) visit the site for its natural aesthetic and recreational amenities. Academic and scholars have already conducted research programs on the wetland and its resources. Also the site is being used for educational excursions for schoolchildren each year.

These values are considered in this study the goods and services currently being supplied by the wetland to the local stakeholders. The main beneficiaries of the wetland resources are categorized in the rest of the paper.

Existing utilization/ conservation of the wetland resources

The wetland as mentioned earlier is located in Mazandaran Province. The area is located within the administrative boundaries of Babolsar Township and districts of Fereydoon Kenar and Roodpost. The nearest city to the site is Babolsar. The total population of the settlements within the area is 17,824 people. The main activities of the local people are agriculture (rice farming), duck trapping, hunting, and fishing. Livestock breeding and commercial activities are other sources of income (Pourlak, 2000).

The site's agricultural lands are flooded during summer, thus supporting groundwater recharge and water supply for irrigation during the dry months. Apart from rice farming, the land is used for forestry and fishery. In the past, a significant part of the wetland areas was utilized for forestry. However, the land areas gradually have changed to rice fields and damgahs. Today, rice farming is the main activity of the local communities within the wetland.

An important traditional activity is duck trapping; originally it used to be a main source of income during the winter months, but is practiced primarily as a sport today. *"During the trapping procedure, domestic ducks are thrown into the air in the direction of the pond. The heavy, poorly flying ducks land noisily in the pond. The sight and sound of these flying and feeding ducks arouse the curiosity of wild ducks in the main flooded field. They swim up the narrow channel to the pond where they are netted by trappers. Because of the height of the brush surrounding the pond and the narrowness of the channel, the wild ducks are unable to take flight and quickly trapped."*.

This traditional method of duck trapping is basically a community-originated approach to the conservation of wetland resources. Indigenous trappers, who are the owners of the lands (damgahs), preserve them from intrusion of stranger hunters, and thus damgahs are being conserved from any kind of degradation or biodiversity loss. The complex system of damgah (about 100 ha) is located south of the town of Fereydoon Kenar in the Mazandaran province of Iran. There are about eighty-five trapping stations along the damgah area, carefully designed by local people as means of camouflage for trapping waterfowl in a traditional method. There are four villages that surround the damgah area, but the trappers using this method are mainly from the nearby villages of Suteh and Mehleban and from the town of Fereydoon Kenar. Other villages in the vicinity of the damgah use hunting methods as opposed to traditional trapping; a matter that, according to the local trappers, significantly disturbs their activities.

The wetland and its surrounding areas are being used by tourists who visit the area from inside and outside the region.

The whole area of the wetland is protected under the control of the Department of Environment for its rich biodiversity.

Therefore, the main local beneficiaries/stakeholders of the wetland resources are:

- farmers;
- hunters;
- trappers;
- tourists; and
- Department of Environment.

Among the main stakeholders, the trappers and Department of the Environment (DOE) are the major contributors to the conservation of wetland biodiversity. Trappers preserve damgahs for income, while DOE applies command and control measures for its protection strategies.

Conservation measures include annual mid-winter waterfowl censuses and implementation of activities agreed upon under a MoU on Siberian Cranes with 9 “range states” of the Convention on Migratory Species. A GEF (Global Environment Facility) project, being implemented through UNEP (United Nations Environment Programme) and coordinated by the International Crane Foundation and CMS, aims to conserve the critical sites used by Siberian Cranes for breeding, staging during migration, and the main wintering grounds.

As a conclusion, there are three types of conservation systems being applied to the wetland:

- Conservation under the national legislative framework, which is under the control of the Department of Environment as the only authoritative body for conservation of nature and biodiversity.
- International agreements and the country’s commitment to Ramsar Convention, CMS (Convention on Migratory Species), and CBD (Convention on Biological Diversity).
- Local system of traditional conservation, which is the duck trapping method used by the indigenous trappers.

Threats to biological diversity

In the past, at the end of each trapping season the area was opened up for gun hunting in a massive “shoot-out”, creating a potential threat to Siberian Cranes that could be shot accidentally. In 2001, the Department of Environment designated the whole site as a Non-Shooting Area. So, over-hunting in the surrounding Ab-Bandans (water reservoirs used for agriculture) is considered to be a major source of threat to the long-term sustainability of the damgah system. These types of activities interrupt traditional trapping and make it less economical to the local trappers to continue to maintain and protect the damgah, as the birds are scared away by the gunshot noise. Illegal hunting has been so far identified as one of the main threats to the wetland, because it leads to decrease in habitat security and in bird population.

Deforestation in the wetland catchment is another threatening factor through increase of soil erosion leading to drastic changes in sedimentation processes and occurrence of eutrophication in the ponds (Lepours) within the wetland.

Use of fertilizers and chemical nutrients in rice fields is another cause of eutrophication and pollution of the water resources of the wetland. Effects of chemicals, particularly pesticides, have increased significantly due to encroachment by farmers on wetland areas during the last decade.

Finally and most importantly, the conflicts among different stakeholders as described above are the major hindering factor in effective conservation of the wetland. Decrease in the number of damgahs, due to encroachments by the rice farmers and to the weak agricultural management of the rice fields in terms of overuse of chemicals, on the one hand, and decrease in the number of observed Siberian Crane during the recent years, which is believed to be a result of gun hunting in a massive shoot-out within the areas near the core habitats of the crane, on the other hand are good indicators of the conflicts. Though the existing self-incentive, traditional conservation methods and the national and international protection activities are still working to control the threats to wetland biodiversity, these control measures are either on just a simple command and control basis or on temporal local community needs. The latter cannot be sustainable in the long run. A market-based approach is required in order to balance the demand to, and supply of wetland resources in a context of a wetland conservation and utilization system. Lack of such an economic basis for conservation can be seen as the main threat to sustainability of the wetland conservation in the long run. This study has focused on an in-depth investigation of the damgah system and its sustainability. The study proposes ecotourism as a viable option to help conserve the wetlands by primarily emphasizing the importance of planning and management in ecotourism.

Supply and demand analysis

This section aims to identify and analyze the costs related to environmental/social degradation and potential benefits of wetland with respect to the economic vs. conservation policies. Taking the significant role of the traditional trapping method (described below) and the potential capacity of the wetland in terms of provision of recreational services to visitors into consideration, a comparative analysis is made to assess the viability of adoption of an alternative market-based approach for preservation of wetland against the current community-driven approach. As mentioned before, the results of an previously conducted study have been used as the basis for economic analysis of the potential costs and benefits (Pourlak, 2000). Given that few studies on environmental economics of natural resources have been conducted and are available in the country, the information provided by the cited study in the Fereydoon Kenar wetland was applied for the purpose of analysis in this paper.

Costs and benefits of ecotourism were weighed in the ecologically sensitive wetland area. As mentioned before, traditional waterfowl trapping by local people has been a key factor in the protection of this valuable habitat, known locally as "damgah". As an ecological hotspot and due to its unique socio-cultural aspects, the Fereydoon Kenar damgah could potentially support ecotourism. Although very few people at the time of the study visited the site, it was expected that the number of visitors will increase in the coming years. The study has focused on estimating the carrying capacity of the site considering limiting factors, such as the number of rainy days, minimum distance required to observe the cranes without disturbing them, and socio-cultural acceptance of local trappers. Contingency Valuation Method (CVM) was used to estimate benefits of ecotourism. The benefits of ecotourism were then compared with costs, i.e. Lost Opportunity Costs.

As a hypothesis of the study and from the market prospective point of view, ecotourism has been discussed as a valuable conservation tool in many studies (Middleton, 1998). At the same time, ecotourism has been criticized for its negative impacts (Wall, 1997). Taking this into consideration, identification of some of the limitations and opportunities that ecotourism may offer the ecologically and socio-culturally sensitive wetland area was assumed as the key factor contributing to the wetland's future conservation policies. Successful ecotourism by definition needs to be "economically sustainable, ecologically sensitive and culturally acceptable" (Wall, 1997). All case studies emphasize the importance of planning and management in successful ecotourism. Three key aspects of ecotourism are to be considered for the purpose of the analysis. These include:

a) protection of the ecological value of the site;
b) participation of local people; and
c) returning some of the income to the local community.

In spite of the fact that ecotourism can be a useful tool for wetland conservation, the sustainability of its application in the long term requires any environmental impacts of the tourism development to be considered in the cost benefit analysis. Although cranes have always captured the attention of man because of their size and beauty, not many studies have recorded the impacts of tourism on cranes. However, a few studies that have done so show that visitors most often disturb the cranes and affect their feeding behavior. A distance of at least 200m is required to reduce this type of disturbance (Ohsako, 1994; Cho & Won, 1990). Results of the studies have shown that Siberian Cranes tend to keep a distance of at least 100m from highly visited sites. The presence of tourists in the wintering habitat of the cranes may interrupt their natural feeding behavior and end up in short- or long-term "fly outs".

A carrying capacity assessment was conducted in order to identify and assess the potential viability of the wetland area for tourism development and the expected impacts of ecotourism development on environmental conditions of the study area. To this end, parameters such as soil, water, vegetation, and climate were studied as potential limiting factors (Makhdoum, 1995). Furthermore, the carrying capacity of the damgah for ecotourism was calculated according to the model suggested by Cifuentes Arias (Ceballos-Lascurain, 1996).

For the purpose of the study and in order to evaluate the costs related to the degradation prevention of the nature and natural resources of the wetland as well as the social costs of the wetland degradation, a typical cost-benefit analysis was made to do the following estimations:

- Estimating the Benefits of Ecotourism including:
  a) income from traditional trapping;
  b) income from tourism.

For the purpose of the above-mentioned estimation, a questionnaire technique was applied through field interviews with local trappers at ten separate trapping stations. The average income for each trapper was calculated on the basis of the questionnaires and the total estimated income for each trapping station was multiplied by the number of stations to estimate the total income from trapping in the study site.

Income from tourism was calculated based on entrance fees only. As no visitors at present frequent the damgah, a questionnaire was designed and distributed through the Internet following the Contingency Valuation Method (CVM) to estimate the approximate willingness of potential tourists to pay (WTP). These were a group of crane specialists registered on the ICF list (forty individuals). In the questionnaire, first the unique characteristics of the damgah were described and then the respondents were asked about the amount they would be willing to pay (WTP) as entrance fees if they were to visit the damgah. To determine a more realistic figure, the average amount was calculated and reduced by 30%. In addition, these rates were compared with other tourism destinations that offer Siberian Cranes as one of their attractions (Keoladeo National Park in India and International Crane Foundation in U.S.A.) to find out if the obtained figures were relatively reasonable.

- Estimating the Costs of Ecotourism including:
  a) Lost Opportunity Costs;
  b) Implementation Costs.

According to this study, the only activity that needs to be halted if ecotourism goes ahead is the present hunting pressure in the surrounding Ab-Bandans, especially in the Rudbast and Khoshkrud villages. Lost Opportunity Costs were calculated in terms of the number of permits that are issued seasonally to these villages. Unfortunately due to time constraints, additional opportunity costs that are probably experienced by other social groups were not investigated in this study.

For implementing ecotourism, the basic capital and operational costs were estimated. Capital costs included information signs, waste containers, washrooms, office furniture, and a computer set. Operational costs consisted of office and field personnel (five in total), communication, transport, workshop, and publication costs.

According to the estimations and calculations, the following results have been made (Pourlak, 2000):

a) The damgah area was divided into three different management zones:
  - Core Zone: Includes Siberian Crane roosting site and critical feeding areas. It also overlaps with the core area that is protected by locals surrounded by 85 trapping stations - Restricted Access.
  - Buffer Zone: Includes nature trails and some trapper stations - Controlled/Limited Access.
  - Transition Zone: Area where infrastructure and facilities may be developed, i.e. visitor centre, observation tower, etc. - No Restrictions.

b) Carrying Capacity for Ecotourists was calculated. The Real Carrying Capacity (RCC) would be smaller than the Physical Carrying Capacity (PCC) and the Effective Carrying Capacity (ECC). Consequently the following results have been made:

PCC = 3300 visitors/day ; where RCC = PCC-Cf1-Cf2-….Cfn

And Cf = corrective factor

Then: RCC = 21 visitors/day

Management capacity of the damgah was estimated to be about 30% of what it needs to be in order to achieve successful ecotourism objectives. This was due to a lack of legal status, management plan, visitor center, guides, educational brochure, entrance fees, fines, or funding for the Keoladeo National Park. On the other hand, the damgah had some management advantages, such as small size, ecological attractiveness, local protection and support, local accommodation facilities.

Then: ECC = 21*0.30 = 6.3 visitors/day

It was concluded that only a maximum of six people may visit the damgah daily. This figure could be a basis for cost benefit analysis in terms of costs related to environmental degradation, which is assumed equal to the costs needed for rehabilitation and tourism development as described above.

c) CVM to evaluate the wetland resources:

The results of interviews with the trappers (ten) show that each trapper spends on average 1,800,000 Rls.[4] per season for the preparation and maintenance of his trapping station. There are about 85 trapping stations in the Fereydoon Kenar damgah. Benefits are calculated based on an average price of birds in the local market of 20,000 Rls. per bird (teals and ducks are not differentiated here). The total seasonal income from trapping has been estimated to be 68,000,000 Rls.

Seven questionnaires out of forty were returned electronically. Assuming that the real WTP is 30% lower than the obtained WTP, the average entrance fees were set up as 14 USD per visitor. By extrapolating this amount to the maximum number of visitors the damgah may have in a season (6 visitors per day*76 days = 456 visitors), the income from ecotourism was calculated. The assumption was that about 20% of the total number of visitors would be international, with reference to the situation in the Keoladeo National Park. Again, using the same example, the entrance fees for domestic visitors were reduced to 25% of the original amounts. The calculations are as follows:

Income from international tourism:

(456*0.20)*135/7 = 1,755 USD

Income from domestic tourism:

14 USD*0.25 = 3.5 USD entrance fee per person

(456*0.80)*3.5 = 1,276 USD

These results when compared to the income from entrance fees in other Siberian Cranes' sites, Keoladeo National Park (India) and International Crane Foundation (U.S.A.), were found to be very reasonable, although lower entrance fees are charged at these sites.

The number of hunting permits issued by the Department of Environment local office for villages surrounding the damgah area was a total number of 98 permits for winter 1999/2000. Considering that each provincial permit costs 25,000 Rls., the Lost Opportunity Costs was calculated as:

98*25,000 = 2,450,000 Rls.

It should be noted that this is the cost endured by the Department of the Environment if the hunting activities are halted. However, further research is required to

[4] At the time of the study, exchange rate for converting Rls. into USD was 1USD=8,000 Rls.

estimate the costs that are inflicted on other social groups especially the local hunters.

To implement ecotourism, capital costs in the field (information signs, garbage disposal, and washrooms) and office (furniture and computer set) were estimated to be approximately 185,000,000 Rls. that need to be invested in the beginning of the project. Operational costs consisting of office personnel (2), field personnel (3), monthly office charges, transportation, communications, workshops, and publications were estimated to be 51,670,000 Rls. per year.

Conclusion and recommendations

It has been shown that in the study area, where the wetland is the only supplier of the natural goods and serves as the basic source of income to the local stakeholders (supply side), there also is a very strong self-incentive for preservation of the freshwater and its natural resources (demand side).

The results obtained for one year (t=1) show that total costs and benefits are not of much different. However, over a five year period, assuming the target number of visitors will be 50, 100, 200, 300, and 456 the total benefits of ecotourism were found to be higher than its costs (NPV>0), except for the first year. NPV increased after the second year of investment, reaching 1,101,011,266 Rls. in the final year of the project. It can be concluded that ecotourism at this site may be used to create additional incentives for the local trappers to continue to maintain and protect the damgah.

Based on the results, it was recommended to conventionalize the community-based approach to biodiversity conservation through involvement of the native communities and clarification of their contributions to utilization of freshwater resources. An integrated management approach comprising two components of tourism market development and a community-driven conservation system is recommended. Such an approach would be the best policy to reconcile conflicts between the stakeholders and to optimize resource allocation and distribution of income among the beneficiaries. The integrated management system aims to ensure sustainability of the functioning of the wetland through combination of three conservation approaches in a time frame of short and long term as shown below:

- Local traditional trapping method;
- DOE command and control measures; and
- Market-based approach through development of tourism activities.

Three scenarios were developed to predict the future situation of the wetland and damgahs. These are listed below:

A) Business as usual scenario:

If the current trends of utilization of wetland resources continues the following situation is predicted:

- Legal gun hunting and shooting will continue within the adjacent Ab-Bandans, and there would be an increasing threat to Siberian Cranes to be shot accidentally. In that case an amount of about 1,200,000 Rls/Crane would be set as the penalty.
- Over-hunting in the adjacent areas (Ab-Bandans) by illegal hunters, leading to biodiversity loss including decrease in the number of the bird species.
- Change of land uses within the damgahs, loss of wetland values, and diminishing of the traditional hunting and trapping methods.
- Increasing conflicts between different stakeholders (hunters, trappers, and DOE).
- Instability of damgah systems within the wetland in the long term.

B) Improving the existing conditions:

The system of damgahs and the local beneficiaries would be subject to changes as below:

- Increased penalty (up to 10 million Rls).
- Control illegal hunting as well as over-hunting.
- Ban the land uses within the damgahs.
- Licensing system on use of aerial bird traps.
- Regular control of damgahs by DOE.
- In this case the main effects would be increasing conflicts between different stakeholders (hunters, trappers, and DOE) and instability of the damgah systems within the wetland in the long term.

C) Ecotourism development:

This scenario would be a combination of control measures as mentioned in the other two scenarios together with a market-based conservation policy, which is expected to result in the following status:

- Income generation for the local stakeholders (indigenous people) .
- Income for improvement of the local settlements.
- Incentive for training and research activities.
- Wise use of the wetland resources.
- More cooperation and consensus among the different beneficiaries.
- Intergenerational transfer of traditional trapping knowledge.
- Raising public awareness.
- Sustainable system of damgahs.

The latter scenario is considered as the best one to achieve sustainable wetland conservation. However, the following recommendations should be adopted to ensure the sustainability of an effective and efficient conservation:

- Effective involvement of local people, particularly the trappers, in conservation activities through application of a co-management approach and sharing the benefits of the tourism activities with them.
- Building legislative capacities or improvement of the existing system of command and control.
- More control of encroachment on the sensitive habitats of the Siberian Crane.
- Conduct research programs on sustainable ecotourism.
- Extension of eco-tour interpretation facilities to visitors.
- Involving NGOs in conservation and ecotourism activities.
- Effective resource allocation and distribution of income from ecotourism among the beneficiaries.

Waterbird Monitoring is planned to be an important activity in the ecotourism plan, as a component of site management (i.e. included in the management plan). A systematic monitoring scheme is required, feeding results into larger national and international frameworks. At present, DOE undertakes the International Waterbird Census each year in January, but no other kind of monitoring is being carried out. The plan also should aim to set up databases on waterbirds and other biodiversity. The participation of stakeholders, especially trappers, in the management of the damgahs is all-important. We cannot produce a site management plan that does not include stakeholder participation. Given that the trappers are out there all of the time, they provide a wonderful resource for monitoring waterbirds, and we should take full advantage of this. They will need to be given some training in waterbird identification, counting methods, and recording techniques. Also some arrangement needs to be worked out for how they are rewarded for their efforts.

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Managing Water Ecosystems for Sustainability and Productivity in North Africa

Chedly Rais

The purpose of this paper is to provide a brief outline of freshwater ecosystems in North Africa (Morocco, Algeria, Tunisia, and Egypt), and assess the sustainability of their exploitation.

Much of the North Africa region has an arid or semiarid climate. Consequently, freshwater ecosystems are relatively rare and are often subject to big seasonal variations. Also, most of the countries experience periods of drought, sometimes lasting many years, causing water bodies to dwindle or even disappear. Although adapted to such variations, most of the region's freshwater ecosystems have difficulty recovering their vitality after long periods of drought, with sometimes profound changes in the ecosystems' main features.

It should be noticed that the situation in the four countries in the region is almost the same, except for Egypt, which finds itself in a different situation due to the presence of the Nile and the complex hydrological system it forms.

From the surface area angle, most of the region's water bodies are artificial lakes and reservoirs, created when dams were built. The dams' main aim was to store run-off water for different uses, and to control the hydrographical systems, particularly protecting against flooding. Exploiting the living resources generated by these inland waters is of secondary importance, and is only borne in mind as a side issue when planning and managing these hydrographical systems (Jackson & Marmulla, 2001).

There is almost no use made of the living resources of the inland waters in Libya, and relatively little use is made of them in Morocco, Algeria, and Tunisia. For the last three countries, the inland waters are an important source of income for the people who live around them, but make only a modest contribution to the national income. However, certain studies show the appreciable potential of making the best use of them. In the case of Egypt, exploiting the living resources of the inland waters constitutes a major economic sector, the main elements of which are fishing and aquaculture.

The dominant feature of the inland water ecosystems in North Africa is their artificial nature both with regard to exploitable species (mostly introduced) and habitats.

Main habitats

Because of the region's climate, only a few types of freshwater habitats are represented in the countries of North Africa where permanent watercourses and natural freshwater lakes are extremely rare. The system for classifying Mediterranean wetlands elaborated by MedWet (Farinha et al., 1996) offers a detailed description of these kinds of habitats. Here we shall merely enumerate the region's main inland water systems that are pertinent to exploiting natural resources. These fall into three categories in the FAO Report Source book for the inland fishery resources of Africa (FAO, 2000):

- Natural lakes
- Watercourses and their related systems
- Reservoirs

We should also mention the freshwater systems of the oases, which are hardly productive in fishing and aquaculture, but play an important role in the local economy of certain areas, especially in tourism and recreational use. These activities play a central role in improving income for local populations of many wetland areas in North Africa (Benessaiah, 1998).

Present uses of living resources in the inland waters of the region

The present direct use most often thought of is that linked to fishing and aquaculture. The rest of this paper will discuss this type of use. However, there are various other uses, such as rush and reed collection, grazing, hunting, and tourism.

With regard to fishing, the main feature of the inland waters of North Africa is the lack of diversity of species that can be exploited for fishing. The native ichthyologic fauna contains few species, most of which are small or of very bad quality. The example of the Barb fish Barbus callensis is very explicit here. This species develops to an appreciable size (several kilograms), but is of very bad quality and fails to attract consumers because of the bad quality of its flesh (Rais & Turki, 1989).

Thus, most of the species exploited by fisheries in the region's inland waters are introduced. Some were introduced long ago, and are seen today as part of the local fauna (Dakki, 1998; Kraiem, 1983). In some cases, species were introduced to check the excessive development of plants or to fight against eutrophication.

The fishing techniques used are often very simple. While know-how is well established for exploiting brackish or marine coastal lakes, and there are traditional fishing techniques, know-how about fishing the region's fresh waters remains relatively undeveloped. Often, fishing is merely an incidental activity practised by farmers or other people. However, this is not the case for Egypt, where inland fishing is a well-developed traditional activity that has been operating smoothly for a long time.

Freshwater aquaculture mainly involves public institutions. Several private fish farms do, however, exist in Egypt, particularly in the Nile delta.

Main features of inland waters in North Africa

Many of the inland waters in North Africa undergo great seasonal variations in their main features, as well as variations in their surface area, according to the seasonal abundance or scarcity of water. So, most of the waters have big variations in salinity. These give rise to profound changes in their populations, and sometimes the disappearance of populations of flora and fauna that are basic for the environment concerned. These changes are not necessarily a handicap, but are occasionally even an appreciable source of diversity and biological richness. Lake Ichkeul in Tunisia is a good example of such a situation. It had been for several years the site of large changes in salinity, going from a freshwater environment (3-4 g/l, according to Lemoalle et al, 1982) in the winter to a salty environment with a salinity like that of the sea (30 g/l or more) in the summer. The diversity of the ichthyologic fauna that resulted from these alternating swings brought about a high fish productivity from this lake. This has markedly declined over the past few years now that the winter drop in salinity no longer occurs in the lake.

The increase in average salinity in the inland waters of North Africa is a general phenomenon. The most spectacular example of this is Lake Qarun in Egypt, originally a freshwater lake, whose salinity has gradually risen to 35 g/l (FAO, 2000).

The attached tables show the changes in the total production of the inland waters of the countries of the region. The data in the table comes from the FAO-SIPAM database, fed by official notifications from the countries. The data shows that inland water production is increasing in Egypt, decreasing in Algeria and Morocco, but remains stable in Tunisia. No data is available for Libya, where there are almost no freshwater lakes exploitable for fishing.

Mode of exploitation

In most cases, private persons fish the region's inland waters with fishing permits or concessions that give them the exclusive right to use a given lake. But there are a few cases where the lakes are exploited by public bodies.

The most frequently used fishing techniques are gill nets and fixed traps, and fishermen often have primitive boats. Marketing is done in a fairly disorganized way, and the product, if not eaten by the fishermen themselves, is sold near the fishing areas.

Can the living resources of the inland waters in North Africa be exploited sustainably? (Threats to sustainability)

The first threat springs from the fact that exploiting the living resources of the inland waters is not a priority; this is so for all the countries in the region, whose first concern is to satisfy drinking water and agricultural requirements.

After the freshwater resources were put to various human uses - particularly agricultural - several of the region's freshwater lakes became much smaller, and some have completely disappeared.

The deteriorating quality of the water is another threat to the sustainability of the exploitation of living resources of the inland waters in the region. This deterioration mainly is due to increased nutrient content, coming both from agriculture and breeding as well as from wastewater being discharged into the watercourses.

Chemical pollution does not seem to be a major problem, at least for the time being. However, the use of motorboats could introduce this kind of pollution. At present, most of the countries in the region forbid the use of motors on their inland lakes.

The introduction of invasive foreign species could pose a particularly important threat and act as a brake on the development of use of the living resources of the region's inland waters. Thus, it is vital to be very careful when assessing the impact of the introduction of any new species.

Finally, the particularly distinct lack of scientific data on the features of the freshwater ecosystems of North Africa poses a threat. Very little is known about the evolutionary dynamics of their biological processes and their populations. Filling this gap is a prerequisite for any sustainable development in the exploitation of these environments.

ALGERIA	1995	1996	1997	1998	1999	2000	2001	2002
Carps and other cyprinids	212	441	231	12	50	50	150	
Eel	19	24	29	32	21	14	44	
Mullets						1	27	
Total	231	465	260	44	71	65	221	0

EGYPT	1995	1996	1997	1998	1999	2000	2001	2002
Carps and other cyprinids	31973	33703	22287	39860	73673	82591	90793	92219
Catfish	200	201	230	197	170	654	656	229
Mullets	14621	20101	16031	28383	42987	80530	96924	113122
Tilapia	28987	29574	30416	52755	103987	157425	152515	167735
Crustaceans							10	90
Total	75781	83579	68964	121195	220817	321200	340898	373395

Morocco	1995	1996	1997	1998	1999	2000	2001	2002
Carps and other cyprinids	600	750	950	1000				
Eel		55				60		
Trouts and other salmons	100	92	100	120		150	100	
Total	700	897	1050	1120		210	100	

Tunisia	1995	1996	1997	1998	1999	2000	2001	2002
Carps and other cyprinids	192	92	253	529	511	401	352	259
Catfish		2	20	14	23	41	72	78
Eel	18	29	34	15	17	20	11	9
Mullets	175	295	485	254	210	294	345	301
Pike Perch	88	142	152	64	48	39	58	56
Other fishes	11	145		22	40	69	25	165
Total	484	705	944	898	849	864	863	868

* Source: FAO-SIPAM database. No data is available for Libya

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Market Role in Conservation of Freshwater Biodiversity in West Asia[1]

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West Asian countries (Bahrain, Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates, Palestine, and Yemen) have, for many decades, faced the problem of decreasing availability of freshwater, which is the habitat for many of the world's biological species. Located in hyper-arid, arid, and semiarid climatic zones, surface water, in most of these countries, is extremely limited due to low`, unpredictable, highly variable rainfall patterns in terms of timing and distribution, and due to high evaporation rates.

Groundwater resources in the region are in critical condition because of the heavy withdrawals for agricultural and domestic uses. These withdrawals far exceed the natural recharge causing mining of the resources. The heavy pressures on freshwater, dictated by increased demands for agriculture, population growth, pollution, urbanization, and industrialization, have resulted in immense loss of the fragile biodiversity resources.

The region faces some serious environmental degradation problems that must be addressed urgently. This degradation is beginning to pose a major threat to the well-being of the population of the region, especially the poor. Furthermore, failure to address such problems will compound the cost and complexity of possible later remedial efforts. Following are some major environmental problems:

- Desertification and land degradation.
- Deforestation and watershed degradation.
- Biodiversity loss due to pressures on freshwater and ecosystems.
- Over-exploitation and misuse of marine and coastal resources.
- Mismanagement of freshwater resources.
- Pressures on human settlements due to water development.
- Pollution of natural ecosystems due to toxic chemicals and industrial wastes.

Issues relating to conservation of freshwater resources, as well as the associated biological diversity and sustainable development, have long been the center of discussions among the international community. Recently, there has been growing recognition among scientists, policy makers, planners, and to some extent even the general public that both freshwater resources and their biodiversity are threatened by human activities and need to be conserved to ensure the survival of mankind.

While expressing serious concern for biodiversity conservation, the United Nations Conference on Environment and Development (UNCED), held in 1992, recommended that all countries should ensure that the conservation and sustainable use of biodiversity become an integral part of the process of making economic decisions. This recommendation was a direct result of growing recognition by scientists, researchers, and policy makers that the current crisis of biodiversity loss is due to the failure of the stakeholders and experts in the field to properly understand the economic aspects of biodiversity resources, and further, due to their failure to reflect the social values of biodiversity in the market arena. The West Asian region is no exception.

This review paper draws heavily on published literature by individuals and international agencies, such as the World Bank and the United Nations Environment Programme (UNEP). The paper briefly describes the West Asian region's freshwater resources, its biodiversity, and the economic considerations and instruments considered essential in the conservation of freshwater biodiversity.

The Habitat and Issues in Biodiversity Loss

Over the centuries, freshwater has allowed the evolution and proliferation of biodiversity consisting of different species to flourish in geographically isolated ecosystems. However, it must be recognized that this rich biodiversity is more vulnerable to extinction than its marine counterpart. This is due to the fact that freshwater ecosystems are more intimately linked to human interventions, which cause habitat destruction by over-exploitation of the freshwater resources, influx of other invasive alien species, and pollution.

[1] This paper was presented at the IUCN Regional Conservation Forum, held on April 5 - 7, 2004, in Amman, Jordan.

Importance and use:
Freshwater ecosystems provide a multitude of goods and services including water supply, flow regulation, waste assimilation, and regulation of climate and atmospheric chemical composition. Additionally, freshwater is the basic ingredient in food, power, and raw material production, as well as recreation. Despite some difficulties in giving a proper value to water due to obvious complexities, the intrinsic value (or non-use services, such as cultural, aesthetic, or scientific values) is also very important.

The traditional concept that water is an inexhaustible resource is changing, with demands outstripping supplies. It is estimated that if the current water management policies are continued, 35% of the world's population will run short of water in the next 25 years. This gives rise to serious consideration at all levels.

Freshwater is a very limited resource in the West Asian Region. In particular, the Arabian Peninsula in West Asia is the most stressed with highly erratic seasonal floodwaters in the valleys. On the other hand, other countries in the region, such as Iraq, Syria, Lebanon, and Jordan, are more blessed with some perennial rivers and streams, notably the mighty Tigris and the Euphrates rivers.

The estimated annual renewable water resources amount to just over 113 billion cubic meters (Bm^3). The annual per capita water availability in the region as a whole, estimated in 1995, was 1,300 m^3. This estimate figure, which includes surface water, groundwater, desalinated water, and reused wastewater, is just over 1,000 Mm^3, a figure internationally recognized as the threshold below which countries start to exhibit signs of chronic water shortages. Also, the spatial distribution of water availability figures is highly varied. For example, in Bahrain, Jordan, and the Arabian Peninsula the annual per capita water availability is only 199, 191, and 380 m^3 per year, respectively – figures far below the threshold limit.

The use of freshwater for different purposes varies from country to country. Overall, the region utilizes 92% of the resource for agriculture, and 7% for domestic uses. The rest is utilized by the industrial sector. The Arabian Peninsula utilizes about 85% of its freshwater for agriculture, while Kuwait uses only 25%.

Major Issues: Globally, freshwater ecosystems are experiencing a significant loss of their biodiversity due to continuous human interventions. In the quest to meet growing demands - warranting development of freshwater resources - many countries have neglected the consideration of biodiversity as an important factor. Available data indicates that around 30% of fish species are threatened – a direct result of habitat destruction. The important factors in the destruction of habitat have been the increasing level of habitat pollution, over-exploitation of freshwater to meet growing demands, and alterations in habitat use. A large number of birds and mammals, depending on freshwater, have lost their main breeding and feeding areas due to the alterations brought about to the freshwater ecosystems.

According to some recent estimates, the last century witnessed a 50% reduction in wetland areas. It will not be out of place to mention that freshwater biodiversity, especially immense invertebrates, have great economic value in sustaining and balancing ecological systems and ecosystem functioning, feeding into large ecosystem-based economic gains. Generally speaking, freshwater biodiversity is more threatened than terrestrial ecosystem biodiversity, perhaps even more than the degrading forest covers in the world. It is increasingly noticed that the loss of biodiversity is the biggest single cost that we may impose on our future generations.

It is encouraging to note that the destruction of freshwater ecosystems is gaining worldwide attention, and that there is growing recognition, even among developing countries, that protection of nature should be an integral part of all water management policies. This change in attitude has developed due to the recognition that alterations to natural freshwater ecosystems are not sustainable, and that preservation of biodiversity and less modified ecosystems could be more beneficial to society in economic and social terms. The growing number of protected areas and national parks (over 65) since 1980 in the West Asian region is evidence of the importance being given to the conservation of biodiversity.

The following are some major issues associated with freshwater use and its management. However, the extent of the problems and their severity vary from place to place and depend on management practices.

- Over-abstraction of groundwater to meet various demands, particularly for agriculture, resulting in:
- Drying up of natural springs and reduced flows of some perennial rivers, whose base flow depended to a large degree on groundwater.
- Drying up of centuries-old systems of underground gravity flow channels known as Aflaj (also known as Karezes in Pakistan and Qinat in Iran).
- Deterioration of groundwater quality due to salinization of upper layers.
- Pollution of freshwater bodies with untreated or partially treated industrial and domestic effluents finding ways into freshwater ecosystems.
- Seawater intrusion into inland areas due to greater use of freshwater in upper riparian areas, in the process allowing lower flows into sea thus causing environmental degradation and salinization of arable lands.

Biodiversity in West Asia

The diverse ecosystems (desert, Mediterranean, freshwaters - rivers and springs, and sub-tropical mountains, to name a few) have increased the region's biodiversity.

Numerous types of fauna and flora species are found in the region. There is extreme dearth of data on species populations in different countries. However, the number of recorded plant species ranges from 301 in Qatar to more than 3,000 in Syria. Marine algae range from 216 in the Persian Gulf to 481 in the Red Sea. There are 21 species of mammals in Kuwait, and 92 in the West Bank and Gaza. The number of birds ranges from 312 in Kuwait to 413 in Saudi Arabia. Reptile species range from 29 in Kuwait to 84 in Saudi Arabia.

Biodiversity loss is one of the major problems faced in the West Asian Region. Indigenous plant and animal life is under increasing threat due to the impact of developmental activities. Overgrazing and mismanagement of rangelands have led to the loss of natural plant cover. Over-fishing, pollution, and destruction of habitat (from land reclamation and wetland filling) all have had a negative impact on biodiversity.

The depletion of groundwater tables in some parts of the region is causing the loss of a unique ecosystem of natural freshwater springs, affecting a large number of plant and animal species. The increased levels of soil salinity - a result of over-abstraction - are causing negative impacts on wildlife and plant species.

Traditional systems of rangeland protection and hunting prohibition have been used extensively in the region to protect natural habitats and conserve biodiversity. However, freshwater habitats are threatened by overuse and pollution, causing loss to associated fauna and flora. In particular, the cultivation of date palm, one of the most important crop plants in the region, has been affected drastically.

Freshwater Biodiversity Loss - Example from Pakistan

The mighty Indus river system, consisting of ten major rivers, travels over 3,000 km from the Northern lofty mountains, draining into the Arabian Sea. Also, the system supports a number of natural freshwater lakes in Pakistan. Moreover, it acts as the bloodline to the mangrove forests extending over 650,000 acres along the seacoast. The freshwater wetlands and their associated biodiversity are seriously degraded, due to the absence of a strong link and coordination between development and scientific institutions. Migratory birds migrate to these wetlands and find refuge there in winters, but excessive hunting and drainage cause excessive damage. Also, in many cases, local communities remain marginalized from the benefits arising from the developments and changes in these natural freshwater rivers, streams, and man-made reservoirs.

Due to extensive surface water development works in the upper riparian areas for diverting water for agricultural use to support increasing food and fiber requirements, the freshwater flow to the deltaic areas has been reduced considerably over the years. In drought years, as witnessed recently, the Indus River remained dry beyond the last development structure almost throughout the year. As a result, not only are the mangrove forests in the deltaic areas of the river - with significant economic value - threatened, but also the freshwater habitats - home to thousands of fauna and flora species and migratory birds - are getting polluted or drying up. Seawater intrusion into inland areas is also causing productive lands to go out of production, with losses of their biodiversity.

Instruments to Conserve Freshwater Biodiversity

The continued overuse of freshwater resources inefficiently causes degradation of habitat, and consequent biodiversity loss. Generally, such loss and degradation of habitats is attributed to government and market failures. The actual culprits (users of freshwater) are not held responsible mainly due to the fact that freshwater, in many parts of the world, is still being considered a "public good", which makes it difficult to place any controls over its access or exclusion of its use.

The Convention on Biodiversity has recognized that biodiversity generates and helps maintain the supply of a myriad of goods and services that are essential for human well-being and economic development. However, biodiversity is under attack by a number of external forces. The most dangerous forces are the underestimation of its value, and a general ignorance of its important role in maintaining the foundation of human well-being and economic growth alike.

Conserving freshwater and related biodiversity can be achieved through various instruments. These are:

1) Direct regulations.

2) Economic (market-based) instruments.

Direct regulations have been widely used throughout the world to achieve environmental management objectives, including biodiversity conservation. Examples are: protected areas, policing against hunting, legislation to reduce/stop over-development of freshwater resources, incentives and subsidies to increase water use efficiencies, etc. Direct regulations are generally inflexible and can impose a high cost on communities and governments. However, such instruments cannot be very useful if they are poorly designed, managed, and administered.

Classic examples from Pakistan of such mismanaged and poorly designed direct regulatory instruments include water pricing structures in the irrigated areas, un-metered water supplies in urban areas, and the flat rate of electricity for pumping water in Balochistan. The first two have been responsible for overuse of irrigation water with the users paying little regard to resource conservation through better and more efficient on-farm practices, and in the daily use of water for domestic purposes. Similarly, the flat rate of electricity for pumping water in the Balochistan province of Pakistan has been acting as an incentive towards drilling more tube wells and uninterrupted pumping of aquifers. In the process, they are causing mining of groundwater with serious consequences. Government efforts to control the situation through legislative measures have miserably failed to check the unabated spread of tube well drilling, mainly due to strong socio-political forces active in the province.

In Mexico, all groundwater is national property and the state regulates construction of new wells and the volume of extraction from existing wells. Strong legislations in force for more than 50 years have failed to check over-exploitation. A study by the International Water Management Institute (IWMI) has recommended that the radical legislations and institutional innovations, tried out with limited success, should be complemented with economic measures to encourage users to accept regulatory controls, and affiliate with participatory approaches. Also, it is recommended that power pricing and supply policy can provide an effective incentive structure for groundwater conservation.

Again, taking the example of Spain, water is treated as a public good, not according to market forces. A study conducted to investigate the impact of water pricing policy on the irrigation sector proves that water pricing, as a single instrument for conserving water, is not a valid means of significantly reducing agricultural water consumption.

Since there are biodiversity goods and services, which are excludable, the private sector may be interested in participating in the delivery of these goods and services. However, the state can help in ensuring that markets are efficient in the provision of non-excludable biodiversity goods and services. Markets promote synergies among local communities, decentralized institutions, transnational companies, and international organizations.

Economic or market-based instruments (MBI) are being used increasingly in many countries as a way to improve environmental quality. These instruments affect the relative prices (costs and benefits) of alternative actions. They aim to influence decision-making and behavior in such a way that assures that chosen alternatives lead to an environmentally more desirable situation than in the absence of such instruments. They generally work by using market signals, such as prices, to provide incentives to decision makers to integrate environmental concerns into everyday decisions. These instruments rely on decentralized decision-making and market mechanisms more than direct regulations do. By creating markets for natural resources and the environment, these instruments can signal true resource scarcities to users, creating economic incentives for wiser management.

MBIs for biodiversity and habitat conservation can be categorized into the following:

- Pollution charges (taxes and user fees to influence the behavior of producers or consumers and discourage environmental damage).
- Tradable permits/credits (that aim to compensate or reverse market failures by addressing lack of clearly defined property rights for a resource).
- Market barrier reductions (removal of legal, regulatory, or other barriers to market activity in natural resources).
- Government subsidies (removing or reforming existing government subsidies).

Such instruments seek to create markets for biodiversity and in this way make biodiversity conservation a genuine land use option for landholders, and an attractive investment option for individuals, companies, government, and other organizations.

A review of lessons learnt from applying MBIs across a wide range of mechanisms in Latin America and the Caribbean has indicated that while MBIs have been successful in raising revenue, other potential objectives, such as reduction of environmental impacts or improving the cost-effectiveness of regulations, have not been attained. The main conclusion is that, for success, MBIs require strong institutions, adequate legislation, and effective monitoring and enforcement.

In conclusion, it can be said that no single policy instrument, whether market-based or direct regulation, will be appropriate for all environmental problems. In fact, the same choice of the instrument will depend largely on the specific environmental issue viewed in the social, political, and economic context of the area where it is to be

Valuation and Incentives for Conserving Biodiversity

It is recognized that economic factors do play a vital role in biodiversity loss or conservation. The stakeholders in biodiversity conservation - mostly local communities in all landscapes - including the government, must be motivated to conserve and use the freshwater resources and allied biodiversity on a sustainable basis. This is possible through valuation of biodiversity and by providing incentives. Valuation of biodiversity is essential to support the decision-making process by signaling where the social values of biodiversity are not reflected in market processes. The incentives may, on the one hand, make it more costly to consume and degrade biodiversity. On the other hand, they may increase personal and social gain in conservation, or may even stimulate the demand for environmentally friendly products. In any case, whatever incentives are created they must become part of a comprehensive framework for action, aimed at biodiversity conservation.

Conclusion

In the West Asian context, and also generally in developing countries throughout the world, the general tendency is to lay greater emphasis on regulatory mechanisms rather than on market forces. Although a few states levy some charges and fees for environment-related services, only a small part of that is used to finance environmental protection schemes. Moreover, the rather weak institutional framework for monitoring and enforcement makes it difficult to realize the charges. Sometimes, the weaknesses in the monitoring mechanism also are responsible for this.

As in most countries of the Asian region, freshwater resources are highly subsidized in the West Asian region. Conservation of freshwater resources generally is practiced through pricing mechanisms, which are beset with numerous problems. Fortunately, however, the pricing and subsidy policies being practiced in the West Asian countries are changing in accordance with the experience gained.

In a decentralized market economy, human behavior is determined by a complex combination of economic, social, and cultural factors. Economic factors focus on incentives offered to each individual or institution. If it turns out that ordinary people have the incentive to destroy components of biodiversity - because of the value and prices assigned to natural resources, nature or individual and collective property rights, the strength and effectiveness of institutions, expectations about the future, the overall economic system, and the economic policies adopted by the government - then we should not be surprised that it actually happens.

The above sets the rationale for the policy role governments can play in this regard. At the national level, it needs to ensure that policies provide incentives for conservation (pollution charges, tradable permits, etc.) rather than for degradation and unsustainable use. Valuation will thus play an increasingly important role in determining the extent of benefits and costs, which in turn is a basis for the use of MBIs. These policies can be adopted at more decentralized tiers of the governments. In any case, the big question to be answered is “are incentives being given to conserve freshwater biodiversity?” At a much lower level, like in protected areas, the question is “how can policy help provide the kinds of incentives that would lead to broad support for the local conservation effort?” Perhaps a combination of options like pricing and valuation, impact assessment, community development, capacity building, and revenue generation through MBIs, such as entrance fees, water charges, etc., could do the trick.

From the water management point of view, the active role of water markets is envisaged in habitat conservation. The way freshwater is used is changing with the increasing practice of developing markets for water rights and water supply systems. The markets are helping in the provision of potential buyers and sellers with incentives to conserve water, and are bringing about equitable and efficient water re-allocations. Private investment in water development and distribution is growing with increasing prospects of charging customers for services. All this will ultimately lead to freshwater conservation. Although some might say that water markets will hurt the poor most, this should be seen in the overall context of increasing freshwater scarcity and loss of biodiversity.

In the backdrop of changing political scenarios and the dynamic economies in West Asia, it is indeed heartening that West Asian countries are moving, if not already there, towards the adoption of markets as institutions for exchange/trade. The growing trend to liberalize and privatize the economy, reduction in subsidies, and the gradual changeover from the concept of "water as a public good" to "water as an economic good" are expected to bring about a positive change in conserving freshwater ecosystems, due to reduced use of freshwater, fertilizers, and pesticides. However, for the full impact of such initiatives to be seen, a monitoring mechanism must be put in place.

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Water-Ecological Problems of the Syrdarya River Delta and Measures to Solve Them

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The tragedy of the Aral Sea Basin has been known for decades in scientific and public circles. Aggravation of ecological tension in this region has been caused in the first place by economic activities. Expansion of irrigated agriculture in the Kyzylorda province - particularly the development of new lands at the upper and middle reaches of the Syrdarya river, coupled with the introduction of more productive and innovative natural-economic complexes, has led to disturbances of the natural environmental balance between aquatic and subaquatic geo-systems, and to the initiation and development of adverse natural processes.

All of these eventually have started to exert negative impacts on human beings. Trends, rates, and scope of desertification processes are characterized by a number of specific features, but human activities have become a decisive factor in determining environment degradation.

Lack of radical enabling political and legal frameworks at the interstate level throws doubt upon the probability of sustaining the Aral Sea Basin nature system as a single whole, in the foreseeable future.

Development of institutional and legal approaches to addressing ecological crises in the territory of the Kazakh Priaralye may be conditionally divided into three periods.

1) During the latest Soviet period (1986-1991), all measures to tackle the Aral Sea problems were initiated from central agencies of the former Soviet Union, which defined the strategy of actions based on federal and regional interests taking into consideration the ecological and socio-economic living conditions of local population.

2) The initial period of independence of the Republic of Kazakhstan (1992-1993) when measures aimed at addressing the consequences of the Aral Sea desiccation were noted for their unjustified euphoria. Some decisions take no account of the realities of the situation and the lack of necessary resources. The Supreme Council of the Republic of Kazakhstan's Enactment of 18 January 1992 "on urgent measures aimed at radical transformation of living conditions for the population in Priaralye" declared the Zone of Ecologic Disaster, which included all districts of the Kyzylorda province, several districts of the Aktubinsk, Chimkent, and Djezkazgan provinces.

3) During the current period, in the course of implementing measures aimed at the elimination of ecological disaster consequences, the Republic of Kazakhstan has encountered considerable economic difficulties. This has compelled the Republic to abstain from adapting the State Program "Aral 2006" and abandon implementation of actions stipulated by the Decision of the Cabinet of Ministers of 25 March 1992, No. 280 "on urgent measures aimed at the improvement of socio-economic and ecological conditions for the population living in Priaralye".

Only lately has the situation started changing for the better.

Implementation of the "INTAS-Aral 2000-0059" project is an important step made by the European Union with regard to evaluating socio-economic and ecological damage caused by lowering of the Aral Sea level. It will justify the necessity of further state measures to protect Priaralye. Similar works carried out with the support of INTAS permitted giving decision makers at the governmental level an understanding of the necessity of adequate measures to provide a new ecologically sustainable nature protection system. (Dukhovny et al, 2001)

The major zone where negative impacts caused by the Aral Sea desiccation are most apparent includes two areas of the Kyzylorda province: the Aral and Kazalinsk districts.

The following key factors give rise to the degradation of nature complexes in the region:

- Disturbance of water-salt balance in the Aral Sea;
- Changes in conditions of lakes in the delta;
- Activation of deflationary-accumulative and impulverization processes;
- Lowering of ground water table and increase in their mineralization;
- Degradation and salinization of hydro-morphological soils of the Syrdarya river basin;

• Overgrazing of pastures and excessive mowing;
• Irrigation and other impacts caused by man.

The dominant factor determining destabilization of the environment is the Syrdarya river flow reduction. During the period of 1961-1970, the Syrdarya river flow diminished down to an average of 6.7 km^3/year, with a minimum flow of 3.2 km^3/year in 1965 and a maximum of 10.6 km^3/year in 1969. During the period of 1971-1980, the average annual flow was 2.3 km^3/year. In 1981-1986, it was 0.72 km^3/year (Fig. 1). In some low-water years the Syrdarya river flow actually failed to reach the sea.

In 1987, the division of the Aral Sea started. The water area was separated by a natural undersea shoal in Berg Straits (level of 40.7 abs m) into two parts: the Small (northern) Sea and the Large (southern) Sea (Fig. 2). The Berg Straits shoal is an important element of undersea relief. It represents a flat, slightly inclined height that is formed by fine and loamy sands and is 14.0 - 15.0 km long, and 17.0 - 17.5 km wide. The Berg Straits shoal, which is located at the level of 42 – 41 abs m, is a natural barrier preventing overflow of water from the Small Sea to the Large Sea. Due to the Syrdarya river inflow a positive water balance started developing, the surplus of which overflowed to the Large Sea. By 1992, the height of overflow between these two water bodies constituted about 3 m: the Small Sea level was 40.2 abs. m, and the Large Sea level was 37 abs m. As a result of these processes, more than 33,000 km of the former sea bottom were exposed, with their inherent lithogenous complexes, forms, and elements of sea relief. (Dukhovny *et al*, -)

In natural conditions within the boundaries of the current delta, the Syrdarya river channel, which spreads over 189 km, provided inflow to the Aral Sea of an average annual capacity up to 490 m^3/sec, supplying the delta with water

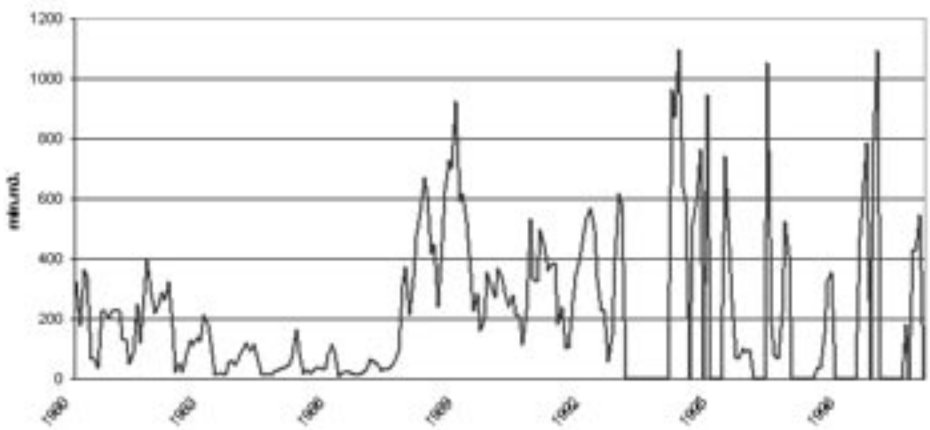

Fig.1: Retrospective analysis shows the share of natural river ow in the water balance of the Aral Sea. With regard to long-term observations, it has uctuated within a rather wide range, especially in the second half of the last century (Table 1).

Table 1: Minimum and maximum values of the Aral Sea levels and total river in ows averaged over time periods

Years	Sea level, abs. m**		River in ow, km^3	
	Min.	Max.	Min.	Max.
1941-1945	52.67 (I)*	52.97 (VII)		
1946-1950	52.68 (XII)	53.03 (VII)	58.6	76.2
1951-1955	52.82 (I)	53.13 (VII)	40.4	64.4
1956-1960	53.13 (I)	53.46 (VII)	28.5	48.6
1961-1965	52.54 (XII)	52.98 (VII)	35.2	81.2
1966-1970	51.29 (XII)	51.69 (VI)	8.2	49.5
1971-1975	49.81 (XII)	50.38 (VI)	7.4	19.3
1976-1979	47.03 (XII)	47.68 (VI)	1.8	10.05
1980-1984	42.75	45.75	0.6 (0.72)	21.8 (2.7)
1985-1989	39.08 (40.50)	41.10 (42.15)	11.41 (2.14)	32.24 (4.9)
1990-1994	36.9 (39.70)	38.24 (42.15)	5.17 (2.62)	28.53 (4.73)
1995-2000	33.98 (39.5)	36.5 (42.20)		

* Values for levels of the Small Sea and months are given in parentheses.
** Values for levels of the Large Sea.

Fig. 2: Dynamics of the Aral Sea water surface changes by year

Table 2: Dynamics of changes of water areas in lakes and wetlands (thousands)

	Names of delta parts and some of the lakes	According to space images, lakes				lakes	wetlands	lakes	wetlands	lakes	wetlands	lakes	wetlands
N N		1967	1981	1989	1997	Aug. 1999	Oct. 1999	Oct. 1999	Jul. 2000	Jul. 2000	Mar. 2003	Mar. 2003	Max.
1	Coastal zone	-	-	-	-	-	-	-	-	-	-	-	3.29
2	Seaside delta												
2.1	Seaside right bank	14.71	6.12	1.4	7.1	0.96	9.4	5.56	5.73	3.53	6.58	2.74	9.4
2.2	Seaside left bank	9.61	4.67	0.55	4.43	0.00	14.23	8.37	2.14	0.77	4.62	1.26	14.23
	Total area in seaside delta	**24.32**	**10.79**	**1.95**	**11.53**	**0.96**	**23.63**	**13.93**	**7.87**	**4.29**	**11.20**	**4.01**	**23.63**
3	Middle delta												
3.1	Kamysh-lybash	26.7	20.10	17.70	21.45	19.18	22.59	16.99	28.16	16.42	34.21	23.26	34.21
3.2	Akshatau	19.8	12.7	10.2	9.97	8.41	15.50	8.27	15.42	8.21	37.42	24.65	37.42
	Total area in middle delta	**46.5**	**32.80**	**27.9**	**31.42**	**27.59**	**38.09**	**25.26**	**43.58**	**24.64**	**71.63**	**47.91**	**71.63**
4	Aksay-kuandarya zone	**37.3**	**29.40**	**8.70**	**12.7**	**11.30**	**27.35**	**12.22**	**21.28**	**9.13**	**64.49**	**43.87**	**64.49**
	Total	**99.12**	**72.99**	**38.55**	**55.65**	**39.85**	**89.07**	**51.41**	**72.73**	**38.06**	**147.32**	**95.79**	**159.75**

at a discharge of about 60 m^3/sec.

The lowering of the northern Aral Sea has caused the activation of river channel processes in the Syrdarya River. Water inflow for the internal lakes of the delta has become constrained and even impossible due to the reduction of the general basis of erosion.

The unsatisfactory condition of connecting canals always has been, particularly at present day, a complicating factor to the situation. Even if the state formerly has allocated certain funding for the reconstruction of connecting canals, today they are in a state of complete neglect. During the period of 1988-1997, many lock gates were destroyed by the spring floating of ice and back waters from lake systems. Repairs and precautions have not been carried out because of lack of funding. Flow capacity of canals has decreased due to vegetation overgrowth, silting, and erosion of embankments. Temporal dams on canals are often washed away, with water flowing back to the Syrdarya river, leading to disturbance of water-salt regimes in lake systems.

In connection to this, the Government of the Republic of Kazakhstan and local authorities have undertaken radical measures to alleviate ecological crises in Kazakh Priaralye. In particular, some ecological stress in northern Priaralye was alleviated by the construction of the Amantkul and Aklak hydro schemes in 1975-1976, as well as the construction of the Kokaral dam in 1998. Unfortunately, all ecosystems restored at that time due to these constructions came to be on the brink of collapse following the breach in the Kokaral dam in 1999 and the Aklak hydro scheme in 2002. The consequent lowering of water levels in the river leads to a situation where substantial amounts of water accumulated in the lake systems outflow back to the river and further on to the sea.

Space remote sensing data allowed the evaluation of actual changes of water area in the lakes, during years of various levels of water availability in the Syrdarya river delta over the last decade:

- In the medium-water year of 1967, water area in the lakes constituted 339.2 ^{k}m2;
- In the high-water year of 1997, water area in the lakes increased up to 429.^{4} km2;
- In the low-water year of 1989, water area in the lakes decreased to ^{2}45 km2 compared with 30^{6}.2 km2 in 1981 (Table 2).

Desertification processes in the downstream parts of the delta have developed and still are developing on a large scale. Also, the ecological situation remains aggravated. Today, moisture conditions in the downstream delta (Aralsk district) remain much as before, far from being favorable. Therefore, processes of hydro-morphological soil degradation continue. The evidence of this is:

- Complete transformation of soils in formerly reed-covered flats and marshes with drying-up soil varieties predominating in the areas of grassland-marsh and alluvial-grassland soils, which have become very highly saline.
- Expansion of takyr-like soils and areas covered with sands and salt marshes (solonchaks). The area of hydro-morphological soils has shrunk in the process of sea delta desiccation from 630,000 ha in 1950s to 80,000 ha today. The total area covered with solonchaks has increased up to 273,000 ha (34%) against 85,000 ha (7%) in 1953. It is expected that, in the future, there

will be expansion of sandy desert soils, takyrs, and residual and dried-up salt marshes. As a result of wind erosion, humus content has decreased from 0.5 - 0.6% to 3-4%.

Based on a similar analysis with regard to South Priaralye, all landscapes are divided into the following types: stable, fully overgrown, partly overgrown, and unstable areas. According to these types, the assessments are given as to vegetation cover of unstable landscapes in the water area of the Small Sea, which is being connected with the designed height of the dam to be constructed on this territory. (Dukhovny et al, 2001)

The work within GIS has been carried out as follows. In the first stage, the areas of all the above-named types of landscapes were determined in 2000 (Table 3). Following that, assessments of current landscapes and those expected to develop under sea level changes reaching 42 m and 48 m were determined (Table 4). Two types of unstable landscapes were defined on the Map of "comparison of unstable landscapes over Syrdarya delta". The first type was defined in accordance with the Landscapes Map of 2000 and the second type was selected on the basis of the Map of Soils, dated 1992. Sandy soils and dunes represent the second type of unstable landscapes. Their total area is 183,782.42 ha. (Dukhovny et al, 2004a)

Data given in Table 3 shows that the rise in the level of the North Sea (the Small Sea) does not exert significant influence on the transformation of landscapes on the dried-up former sea bottom in the northern part of the Aral Sea. Therefore, detailed assessment of landscape changes on the dried-up former Small Sea bottom has been carried out with regard to rise of water level to 42 and 48m. The relevant data is given in Table 4.

At present, the total area under all types of landscapes on the dried-up Small Sea bottom is 788,527.7 ha. When the Small Sea level rises up to 42 and 48m, landscape areas will be 736,997.9 ha and 587,061.6 ha, respectively.

When the Small Sea level changes, the unstable sea bottom landscape area decreases by 31,155.6 ha at the sea level of 42m, and by 83,255.6 ha at the level of 48m. Since some recharge from groundwater occurs at the level of 48m and part of unstable landscapes will be transformed into overgrown landscapes, the area of unstable landscapes will decrease against the current state by 98,817.9 ha.

Apart from this, if designed hydro-technical schemes are constructed or restored, the area of unsustainable watering (defined as the second type of unstable landscapes) will be partly covered by water and will be 119,742.79 ha.

Intensification of wind erosion processes and the removal of salt and dust from the dried-up bottom of the Aral Sea to adjacent territories are among the major causes of desertification in Priaralye. Experimental field surveys revealed that long-term average values of sand/salt removal beyond the dried-up sea bottom amount to 7.3 million ton/year, while salt constitutes 0.7 - 1.5% of all removed solid mass. Thus, the average annual amount of salt removal from the Kazakh part of the dried-up sea bottom constitutes 50,000 – 70,000 ton/year.

In general, ecological disaster in this region has caused the sharp deterioration of living standards of local population in coastal zones, particularly in the delta, as well as loss of income. This, coupled with water scarcity, has created a critical socio-economic situation in the region.

Analysis of available materials provided by partners, information obtained during visits to the Syrdarya delta, and interviews with local population lead to the conclusion that the issue of water body management needs to be addressed. First of all, it concerns natural lake system management. Issues of guaranteed provision of water supply and lake system management need to be addressed on the basis of a thoroughly elaborated scheme of ensuring water inflow to all lakes of the system, establishing infrastructure for research, and the regulation of water transportation to the Northern part of the Aral Sea. It is impossible to work out a more or less reliable long-range forecast with regard to the evolution of the situation without in-depth and comprehensive analysis of ongoing processes in the region.

The economic and ecological damage caused by the Aral Sea desiccation and reduction of river runoff flowing into the delta basically is evident in losses relating to fishing, cattle-breeding, transport navigation (fleet of boats, port facilities, harbors, moorages, and canneries), stocking up reeds, muskrat trapping, etc. Most important are the negative impacts exerted by the sharp deterioration of the environment on people's health in this region (Table 5). (Ruziev & Prikhodko, 2003)

For the purpose of improving the ecological and socio-ecological situation in Priapalye, Heads of Central Asian states approved in January 1994 the program "on concrete actions to improve the ecological situation in Priaralye for the period of 3 - 5 years, taking into account socio-economic development of the region – major directions" (PASB).

At present, the draft has been developed "on regulating

Table 3: Areas calculated according to the Landscape Map of 2000 with regard to all Kazakh Priaralye (ha)

Landscape	Stable	Unstable	Overgrown	Partly overgrown
Current state*	265,303.2	1,585,325.8	549,058.2	237,034.9
Dam level at 42 m**	257,722.2	1,552,946.8	547,971.3	224,581.3
Dam level at 48 m***	251,681.8	1,499,677.7	940,550.3	204,181.5

* 2000
** filling the Small Sea to the level of 42 m
*** filling the Small Sea to the level of 48 m

Table 4: Areas calculated according to the Landscape Map of 2000 with regard to the Small Sea area (ha)

Landscape	Water area of the sea	Area under conditions of additional in ow rising sea level ****	Stable	Unstable	Overgrown	Partly overgrown
Current state*	249,840		123,658.3	368,406.4	209,073.8	87,389.2
Dam level at 42 m**	310,550	60,710	116,932.8	337,250.8	208,014.4	74,799.9
Dam level at 48 m***	456,290	206,450	101,438.1	285,150.8	145,942.1	54,530.6
Recharge at the level of 49.50 m			98,603.1	269,588.5	123,731.2	47,452.6

**** Areas covered by additional watering are given at levels of 42 and 48 m

Table 5: Breakdown of damage caused by the ecological disaster of the Aral Sea desiccation in Kazakh Priaralye (per year)

Damage components	Amount of damage (million USD a year)
1. Losses in agriculture (total)	25.8
Including:	
Irrigated agriculture	13.5
Fishing	2.6
Muskrat trapping	0.3
Meat production	5.8
Dairy production	3
Muskrat fur trade	0.8
2. Losses in recreation and tourism	4.3
3. Indirect losses in industries (total)	5
Including:	
Fishing	0.8
Muskrat fur processing	1.6
Reed processing	2.6
4. Reduction of freight by sea and river transport	0.3
5. Social losses (total)	14.1
Including:	
Damage caused by migration processes	1.1
Indirect compensation payments to the population living in adverse ecological conditions	11.3
Damage caused by reduction of life expectancy	0.4
Damage caused by increase in sickness rate of the population	1.3
TOTAL DAMAGE	49.5

the Syrdarya river channel and the Northern Aral Sea". First and foremost objects were selected for implementation (investments are stipulated at 78.25 million USD). Construction works started in 2003. Among these objects are:

- Dam and a spillway to the Aral Sea - 23.2 million USD
- Hydro scheme Aklak - 17.6 million USD
- Hydro scheme Aytek 15.25 million USD
- Major repairs of Kyzylorda and Kazalinsk hydro schemes - 4.4 million USD
- Protection dams - 3.7 million USD
- Rehabilitation of Chardara Dam - 14.1 million USD

Analysis shows that to solve the problems, in addition to planned measures (construction of CAM, reconstruction and rehabilitation of hydro-technical structures, and protection dams) full implementation will require the construction of dams in the end-parts of lakes (about 36 km), canals (about 15 of conveying, diversion, and connecting canals), and head hydro technical structures on these canals.

If sustained at a certain sea level (47 - 47.5 abs m), the Small Aral Sea will be the end-reservoir for northern Kazakh Priaralye. It would meet the requirements of nature (for migrating birds, transport, improvement of climate, etc.) and serve socio-economic and ecological functions (mainly ensuring sustainable fishing and other economic activities) that would improve the welfare of the local population.

In general, the Syrdarya river delta is a very complex water management system with water facilities scattered over the large territory. Every facility represents a compound network of connecting and feeding canals, tens of kilometers long, with numerous water bodies intended for various purposes. All this network of water management facilities needs is to be organized in compliance with the requirements of nature in the first place, and according to socio-economic and ecological objectives. To this purpose, special detailed field surveys are required in the lower reaches of the Syrdarya river and in the northern part of the Aral Sea, so that measures to sustain and regulate the water/ecological situation in the region could be implemented based on scientific and engineering justification. Since the issue of creating controlled wetland complexes at the lower reaches of the Syrdarya river has not been studied sufficiently, it is necessary to thoroughly clarify contents, scope, and regime of operating water bodies and connecting canals with the application of modeling and simulation tools. Clear justification is needed as to what lakes should be preserved - what parameters (area of water surface, depth) and what regimes of water inflow should be taken into consideration, and which lakes are to be excluded from water management system as inexpedient.

Apart from the above-mentioned additional measures, there is a necessity to establish a consortium (or some other water association) for delta management, which could perform its functions with the participation of all water users and other stakeholders, including governmental agencies and provincial authorities. This organization should arrange its interrelations with BWO "Syrdarya" on a contractual basis, collecting charges for mutual services and clear definition of reciprocal obligations.

Suggested measures imply the stabilization of the situation in the Priaralye delta zone and the provision of guaranteed water levels in lakes, and will facilitate restoration, protection, and well-balanced use of water resources. They could become a key factor, which allows rapid retrieving of a normal state for currently distorted ecosystems and retains the NAS in the capacity of a natural object.

Major consequences of the Aral Sea desiccation, alongside the reduction of its volume, water surface area and aggravation of mineralization processes, are reflected in the formation of a vast salt desert on the dried-up former sea bottom, the area of which has reached almost 3.6 million ha. As a result, the unique fresh water reservoir has been replaced by a vast bitter saline lake combined with an enormous salt-and-sand desert located at the junction of three sand deserts. In 1985 – 1986 when the sea level reached 41 abs m, the full partition of the Small Sea from the Large Sea took place. This led to the formation of a new desert territory covering an area of 6,000 km2 with salt storages in the topsoil layer reaching up to 1 billion ton. Thus, the Aral Sea, a single inland lake in the past, will become in the nearest future a set of separate water bodies, each with its own water-salt balance. The fate of the future depends on what policies the five Central Asian countries will choose to pursue with regard to the Aral Sea. (Dukhovny et al, 2004b)

Reduction of the river runoff to the delta has caused a decrease in inflow to all delta lakes and flood plains of the Syrdarya river, bringing ecosystems to the brink of collapse and exceeding the bounds of socio-economic and ecological problems of the region.

If the current situation in the Syrdarya river delta and in Priaralye in general is not changed, then the critical ecological situation here will be retained.

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The Promise for Freshwater Biodiversity Conservation in Central Asia: Focus on the Aral Sea Basin

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Although the Central Asia subregion is biologically diverse, it suffers from many environmental problems and is the most degraded area of the former Soviet Union. During the second half of the twentieth century, the natural environment of Central Asia has changed dramatically. The areas under grain and cotton production expanded far beyond the traditional boundaries of the ancient irrigated oases. These changes were exacerbated by the large scale development of oil, natural gas, iron, and copper, as well as the rapid expansion of the cities and industrial settlements. A massive system of irrigation was created, stretching for thousands of kilometers and accompanied by a vast network of hydroelectric stations and reservoirs (IUCN, 2004).

The meteorological monitoring conducted during more than 100 years in the region has shown the positive trend of air temperature, and thus, allow us to conclude that tendency to climate warming is observed within all territories of the region either in the cold or in the warm half of the year (Fig. 1).

Central Asia has experienced similar air temperature trends to those observed at global and regional scales. Thus we can conclude that regional climate change reflects global warming trends (Fig. 2).

The assessment of the possible changes in the air temperature in the climatic zones of Uzbekistan and adjacent mountain territories for the scenario of the emission of greenhouse effect has shown that till 2030 the most significant effect of global warming can be expected in the north-western parts of the republic. Moving south, the effect becomes weaker; the weakest effect will be observed in the adjacent mountain areas. Empiric statistic evaluation of the average annual temperatures recorded the annual changes as being between 1-3°C.

The increase of the winter temperatures varies also from 1 to 3°C. Outside Uzbekistan, in the southern regions of Central Asia, the forthcoming warming does not exceed 0.5°C in summer and 1°C in winter. In the high mountain vast depressions of Tien-Shan and Pamir-Alay, the summer warming reaches 1°C and winter warming reaches 2°C. The autumn warming in the depressions is commensurable with the levels of the plains.

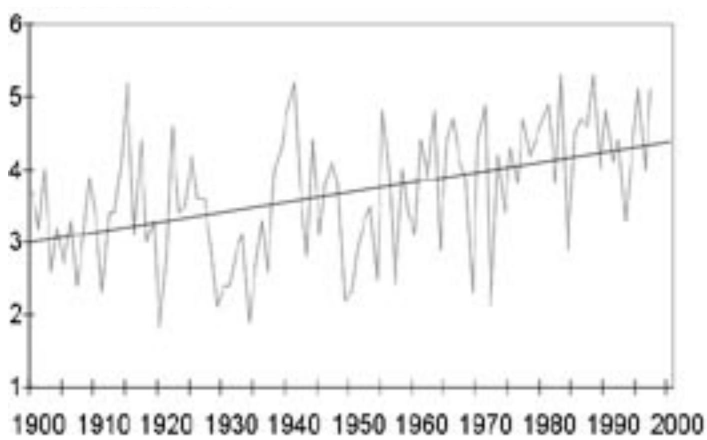

Fig. 1: Annual average air temperature of Tashkent (Uzbekistan) during 1900-2000.

According to the natural climate conditions in Central Asia the most typical regional ecosystems were desert ecosystems of the plains, semi-deserts and steppes of the foothills, river and coastal ecosystems, wetlands, and mountain ecosystems.

Each of these ecosystems presents a complex of natural components that determine the development and functions of plants and animals associations. Ecosystems of the plains occupy more than 70% of the territory, and mountains stretch over other areas where the main river runoff forms (Shults, 1958; Talskykh, 2001). In the case of the warmth (heat) abundance in the arid zone, the limiting factor for the development of natural ecosystems in the region is water resources. Therefore, the rich and productive regional ecosystems basically were located in the flood-lands and deltas of rivers (Chub et al., 1998).

The mountain area of Central Asia, with its diverse precipitation distribution (60 – 2,500 mm per year), has 3.5 times more water resources than the flat (plain) areas. It gives these resources to lower plains - basically, as surface runoff - where intensive dispersion and evaporation take place. The territorial connection between desert, steppe areas, and water-bearing rivers cutting through them results in the development of intensive use of these rivers for irrigation purposes in the dry plain areas. Thus, economic activity of human societies has been the main factor leading to changes in the rivers runoff since the ancient times.

The different trends of the flowing processes in the mountains and within the plains gave grounds (Shults, 1958; Agaltsova & Borovikova, 2002), in Central Asia, to the selection of the area of flow formation, corresponding the mountain elevations and area of drainage (flow) dispersion where the flow use for irrigation and evaporating occurs.

Climate changes and possible consequences on water resources

The current climate change leads to the activation of global hydrologic circle and essentially influences the regional water resources. The conditions of the formation of water resources are changed, resulting in changes to the rectangular components of the water-balances in the river basins and types of river supplies. The data of long-term periods of hydro-meteorological monitoring in the region has shown that the current global warming is apparent in Central Asia. The trends of some components of the hydrologic circle, such as the increase of evaporation layer, decrease of snow accumulation, and significant decline of the mountain glacial forms, are observed (Fig. 3).

The calculations realized on the mathematic model of the water flow forming under the condition of various scenarios of climate change indicate that in the considered diapason of climate parameters changes during the next 20-30 years the water resources' changes will not be very evident. However, in the condition of climate warming, the average discharges of water for the vegetation period will decrease. The possible changes of flow in this period will vary naturally from +3-10 to -2-7%. The change of annual inflow of the main rivers of Central Asia – the Amu Darya and Syr Darya – can differ significantly under various scenarios of climate change (Fig. 4).

Fig. 2. The changes of average annual global air temperature and air temperature at the stations of Uzbekistan and 10-year slippery average values.

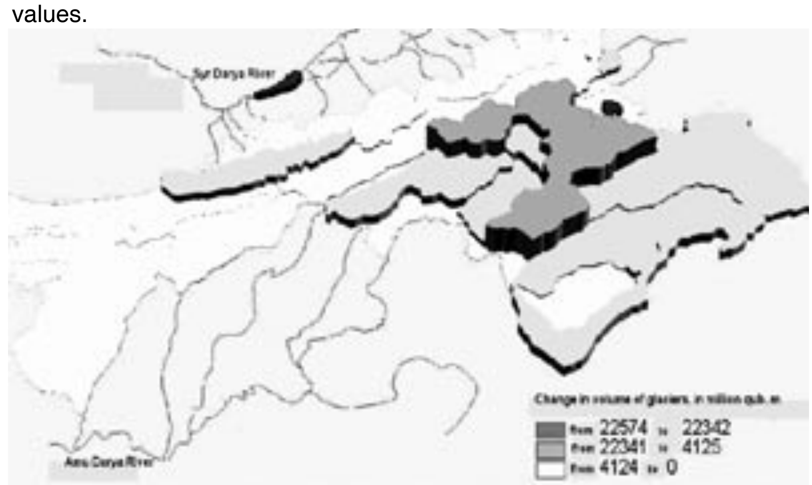

Fig. 3. Changes of the Pamir-Alay glaciation extent during second part of 20 Century.

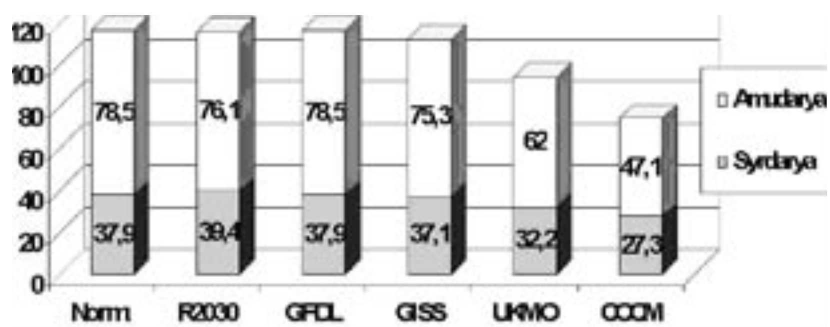

Fig. 4. The annual runoff of the Amu Darya and Syr Darya Rivers under various climate change scenarios: CCCM – The model of Canadian Climate Centre, spatial resolution - 2,22° in latitude and 3,75° in longitude; UKMO - The model of UK Meteorological Bureau, spatial resolution - 2,5° in latitude and 3,75° in longitude; GFDL-The model of the Laboratory of Geophysical Hydrodynamics, USA, spatial resolution - 2,22° in latitude and 3,75° in longitude; GISS - The model of the Goddard Institute of space research, USA, spatial resolution - 7,83° in latitude and 10,00° in longitude.

Role and essential features of the inner freshwaters

Most parts of Central Asia are located in the arid zone within the area of inner drainage of the Aral Sea basin. The water resources of this territory are constituent part and regulators of all terrestrial and aquatic systems with interaction of main elements of hydrological circle and concomitant migration of chemical substances. Water resources of the region present the base for the sustainable survival of natural and ameliorated environment, and play an important role in social economic life of local human populations. The peculiar properties of hydrologic circle, the basin of the Aral Sea is divided into areas of formation, dispersion and transit of drainage that mainly corresponds with mountains, foothills and flat territories. The most distinctive peculiarity of the hydrograph network and water resources of the region is their extremely uneven distribution within the territory. For most parts of the plain area, the layer of atmospheric precipitates does not exceed 100 mm per year. Under the condition of potential possible evaporation of 1200-1800 mm per year, the drainage is not formed from this territory.

According to the orographic, hydrographical, and geomorphological peculiarities, the territories in Central Asia are divided to two large areas with principal distinctions. These include the plain area, which occupies almost 70% of the territory where there are no rivers; and the mountain area where all rivers are generated for the whole region. The main origin of forming of water resources, as everywhere, is the moisture borne by air. In average, over Central Asia about 2,700 km3 of water are transferred with air masses per year. About 490 km3 of water fall on the territory as atmospheric precipitation. In the Central Asian region, there are 89,000 rivers and about 5,900 lakes (Table 1). According to data of N.L. Korzhenevsky, the density of river system in the mountains of Central Asia is 0.617 km/km^2, and in the plains is 0.02 km/km^2. The value of water resources in the region has been estimated several times by different scientists on the basis of observation material for the gauging-station network in hydro-meteorological services of the region. Nowadays, it could be concluded that the value of surface water resources of Central Asia has been determined quite precisely.

Origin and estimations of freshwater resources

Water resources of rivers are generated in mountain systems of Tien-Shan and Pamir-Alai due to thawing of seasonal snow, glaciers and atmospheric precipitation. In the states of Central Asia, the majority of water resources are formed in Tajikistan (36%) and Kyrgyzstan (34%); water resources forming in Uzbekistan and Turkmenistan do not exceed 8.03% of the region's water resources. Kazakhstan is responsible for the formation of only 5% of the water in the Aral Sea basin.

In accordance with the type of water supply, which depends on prevalent height of the catchments basin, all rivers of Central Asia are divided into 5 categories (Table 2). These categories define rivers' water content, hydrological and temperature regimes, and other ecological features and peculiarities.

As it was mentioned above, the largest part of Central Asia is located in the area of the inner drainage of the Aral Sea basin where the main river runoff concentrates in the biggest trans-boundary rivers of Amu Darya and Syr Darya. The largest in terms of water content is the basin of Amu Darya River. Its total catchment area in the zone of flow forming, including the drainage areas of Zaravshan and Kashkadarya rivers, occupies 227,300 km^2 and provides the plains with about 79 km^3 of water. The catchment area of Syr Darya River is estimated at 150,100 km^2 with river flow of about 38 km^3 (Shults, 1958). The lakes are mostly located in the valleys of the rivers. They have various origins: the mountain lakes usually descend from stone obstructions or glacier origin, and the plain water-bodies in the last decades mostly are formed (generated) by drainage waters. These are the drainage-overflow (secondary or man-made) lakes, which are widely distributed either over the same places of former natural lake systems, supplied by river waters, or, to a greater extent, over secondary artificial water reservoirs formed in the last 20-40 years in the depressions of landscape as a result of break flood or drainage flow from the irrigated areas (Gorelkin et al, 2002; Gorelkin,

Table 1. Distribution of rivers and lakes in the main regions of Central

River basin, region/ number of water bodies	Rivers		Lakes	
	Total	Length > 10 km	Total	Area > 1.0 km^2
Amu Darya	40999	1787	2619	129
Syr Darya	29790	1907	1405	65
Talas	3632	276	467	23
Chu	5244	491	506	38
Sarydzhaz (Chinese Aksu)	4495	214	260	4
Issyk-Kul Lake	1976	134	183	20
S. Turkmenistan	2972	167	211	42
Total:	89018	4978	5961	321

Table 2. Types of river supply in Central Asia

Prevalent type of supply	Characteristic features
1.Glacier – snow	Full- owing and cold-water rivers with extended ood having the peak in s`ummer-autumn and summer vegetation period. They have the weak development of water biota and comparatively high stagnancy related to climatic factors.
2. Snow – glacier	
3. Snow	Intermediate type with spring-summer more short period of ood and less stagnancy related to climatic factors.
4. Snow-rain (pluvial)	Rivers containing little waters with short period of spring ood, intensive summer warming-up of the water mass, and good or abundant development of water biota. They are sensitive to change in climatic factors, and characterized by pronounced seasonality of hydrological and biological phases during the year.
5. Ground-rainy (pluvial)	Rivers and streams containing little waters with very short spring ood period, abundant development of water biota, and prevalence of the heterotrophic components in the structure of water biocenoses. They are extremely sensitive to change in climatic factors and state of adjacent terrestrial landscapes.

1988). Their overall volume in the basin of Aral Sea exceeds the volume of all water reservoirs (Gorelkin, 1988). So, at present, the water resources of the region are presented in average by 113.3 km^3 per year and collected in the two biggest basins of the Amu Darya River (73.5 km^3) and Syr Darya River (38.8 km^3) (Table 3). The area of ice (frozen area) in the basins of these rivers is 16.6 thousand km^2. The volume of ice in the glaciers of Gissar-Alay is estimated at 88 km^3, and in the glaciers of Pamir at 465 km^3. The amount of water in the mountain lakes of Amu Darya basin is 46.6 km^3, and in the lakes of Syr Darya basin is 5.6 km^3. The lakes mainly are located in the valleys of rivers. Mountain lakes generally are defined as having goaf and glacial origin, but the lakes of the plain area are formed by drainage water. The irrigation-overflow lakes are formed on the edges of the irrigated lands in the natural falling of relief. Such lakes as Aydar-Arnasay-Tuzkan, Sarykamysh, Dengizkul, and Kamashlybash in their existing sizes were generated from drainage waters at places of local depression. The volume of water in the lakes of plain territory, not including the Aral Sea, is approximately 70 km^3. In the last 60-70 years, the natural regime of drainage in Central Asia was distorted by the diversion of flow for arable irrigation, replenishment of water reservoirs, and discharge of drainage waters. Within the area of Central Asia, 98 water reservoirs, which are still functioning today, were built. The biggest of them allows regulating the long-standing water flow in the Syr Darya basin and the seasonal water flow in the Amu Darya basin.

The abundance of solar energy and presence of the vast plain areas determined the intensive development of irrigated farming (arable agriculture). In connection with this, the demand on water resources, especially in the middle of the 1960s, increased sharply and water consumption tripled (Crisis of Aral, 1995). From the total water inlet in Central Asia (117.7 km^3 per year), 108.4 km^3 or more than 90% of water resources are being used in the zone of intensive water consumption. For the satisfaction of the needs of the growing agriculture and human population in the basin of Aral Sea, the complicated irrigational economy from connected natural water currents, artificial water reservoirs, integral water-intake station and arable channels of the drainage system was created (Talskykh, 2001). However, due to low efficiency of the majority of water facility systems, enormous irrevocable loss of water exists (Environment 2003). In the basin of the Aral Sea, a system for the regulation of the river flow was created. The system included the significant number of channel basins and water reservoirs with a volume of 60 km^3, 33.4 km^3, which belong to the water reservoirs of the Syr Darya basin with a river discharge of about 38 km^3 per year almost completely regulated runoff (Table 4).

Water quality

In general, the quality of river waters based on integral biological indexes (25, 35) is still high (very pure or pure waters) with mineralization ranging from 89-309 mg/l to 420 mg/l. Specific contaminants, such as heavy metals, phenols, oil products, and pesticides do not exceed or slightly exceed MPC (Maximum Permissible Concentration). Therefore, the quality of the water allows its use without any limitation for all sorts of water consumption. In this context, this water is used widely in the lower oases, even for drinking purposes. The river systems of the flow forming zone are significant for their biosphere importance; being the original centers of mountain landscapes that support the balance of the terrestrial ecosystems. However, the processes of degradation, such as disafforestation and soil erosion, overgrazing, and waste pollution,

Table 3. Water resources (km^3/year) of the rivers in Central Asia

River basins	Average multiyear discharge, m^3/sec	Annual ow volume, km^3/year		
		Average	Max.	Min.
Amu Darya basin:				
Pyandzh	1140	35.91	-	-
Vakhsh	661	20.8	27.60	16.2
Kafirnigan	187	5.89	9.81	4.09
Surkhandarya and Sherabad	127	4.00		
Kashkadarya	49.0	1.56	2.72	0.897
Zerafshan	169	5.32	6.86	3.81
Subtotal:	2334	73.50	-	-
Syr Darya basin:				
Naryn	448	13.8	2.34	0.817
Fergana valley rivers	401	12.8		
The rivers of the northern side of Turkistan ridge towards the west from Fergana valley	9.63	0.30	0.446	0.225
Akhangaran	38.5	1.22	3.04	0.557
Chirchik	248	7.82	14.15	4.53
Keles	6.67	0.21	0.507	0.088
Arys	64.2	2.02		
The rivers of the southern-western Karatau ridge	21.1	0.663		
Subtotal:	1237	38.83		
Kyrgyzstan:				
Talas	68.0	2.14		
Chu	137	4.33		
Issyk Kul Lake	118	3.72		
Sarydjaz (Chinese Aksu)	225	7.07		
Subtotal:	548	17.26		
Turkmenistan:				
Atrek	9.85	0.30		
Tedzhen	27.0	0.85	0.530	0.093
Murgap	53.3	1.68	2.60	0.373
The rivers of the north Kopetdag ridge	10.4	0.33		
Subtotal:	101	3.16		
Total:	4219	132.77		

are increasing in the mountains. The zone of intensive flow consumption shifts to the flow forming zone due to expansion of urban settlements and recreational zones.

In the zone of water flow forming the absolute majority of the rivers, lakes, and water reservoirs are characterized by high water quality, although in the inland basins salty (Issyk-Kul and Karakul) and salty lakes (Rangkul and Shorkul) exist. In the glacier zone, the water-mineralization is 100-150 mg/l, in the middle zones of mountains it is 200-300 mg/l, in some foothill places it can reach 500 mg/l. Content of specific pollutants (oil products, metals) does not exceed or slightly exceeds the MPC (Maximum Permissible Concentration). In general, the quality of water in the region is suitable for the basic types of water consumption. However, in the last years, the dangerous trend of a biological intensification processes (eutrophication) was noted. This trend, which is possibly due to recreation load increase and to the drawing of water from small rivers without control, has resulted in the deterioration of water quality.

The quality of national and trans-boundary waters in the consumption zone of water flow, under the influence of regulatory processes and anthropogenic pollution, is bad. The transformation of water flow quality is more evident in the increase of mineralization levels in the river courses. Increase of mineralization is connected with concentration of all mineral components downstream. The most significant changes occur below the big collectors flowing into the rivers. During the past ten years, the following tendencies concerning change of superficial water quality were noted:

- Stabilization of the mineral composition and delay of mineralization growth;
- Decrease of general level of organic pollution and level of saprogenity of currents, as the average annual concentrations of ions of pollutants (nitrates, oil products, pesticides, phenols, and metals) in the zones of increased anthropogenic influence, which is connected with the decreasing of technologically outmoded (obsolete) plants and with high-water levels by the end of 1990;
- Increase of water eutrophication of the small and medium rivers in the mountain -foothills belts as a result of urbanization and recreation processes.

Table 4. The volumes of the water reservoirs in the basin of Syr Darya River

Water reservoirs	Country	River	Total amount (km^3)	Useful amount (km^3)
Toktogul	Kyrgyzstan	Naryn	19,5	14,0
Chardara	Kazakhstan	Syrdarya	5,2	4,7
Kairakum	Tajikistan	Syrdarya	3,4	2,5
Andizhan	Uzbekistan	Karadarya	1,9	1,75
Charvak	Uzbekistan	Chirchik	2,0	1,6
Others			1,4	1,2

Ecological risks related to the use of water resources and natural events

Among the possible negative influences of water resources on humans' sustainable development and biodiversity conservation are the spontaneous hydro-meteorological events, particularly the catastrophic floods, mudflows, and water-breaks, including breaks of mountain lakes. In Central Asia, 23 large mountain lakes can be broken by water as a result of unexpected natural events; the Sarez Lake is the biggest among them. The problem facing Sarez Lake is its possible break through of the natural Usoy dam. In case of its failure, a catastrophic flood will occur in the valleys of the Bartang, Pyandzh, and Amu Darya rivers. It is estimated that the flood will affect as area of 69,000 km^2 in Tajikistan, Uzbekistan, Turkmenistan, and the Islamic Republic of Afghanistan, with a total population of 6 million people. The height of the wave could reach from 17 to 34 m, and all objects of human settlements, agricultural lands, vegetation, and animals would be annihilated in this case. Lake Sarez was formed on February 18, 1911 as a result of 9- to 10-point (Richter scale) earthquake, which caused a 2.2 cubic kilometer ground mass to hang over the Murgab River valley. Water in the lake is fresh; its volume is 18 km^3. Its surface area is 86.5 km^2, and its length is 80 km with a maximum width of 3.68 km. The average depth of the lake is 200 m, and its maximum depth is 505 m. Lake Sarez is situated at the altitude of 3,252 m above sea level, and this a significant danger because in the event of breakthrough such a large amount of water flowing down from the altitude of over 3,000 m will create a powerful torrent with a high velocity, destroying everything along its course. From 1913 to 1995, the water level raised about 187 m. At present, the volume of water in Lake Sarez is still increasing. Due to water seepage through Usoy natural dam, water upwells up in springs, which have formed a canyon 2 km long and 30-35 m deep in the downstream of the Usoy dam. Flow rate through the Usoy dam is 44.6 m^3/sec. The unstable regime of Sarez Lake in the twentieth century and possible future changes caused by the global climatic changes require greater attention to the hydro-meteorological aspects of the Sarez Lake problem, particularly to urgent restoration and development of adequate hydro-meteorological monitoring system.

Transformation of the Aral Sea basin as a result of human activity

The intensive developments in the region during the second half of the twentieth century led to considerable changes to hydrological and hydro-chemical regimes of water surfaces causing many ecological problems. Numerous investigations have been carried out leading to the assessment of the influence of anthropogenic factors on the regimes of rivers, canals, collectors, lakes, and water reservoirs. Especially in the basin of the Aral Sea the changes had multi-scaled consequences (Fig.5), because the redistribution of water has resulted in change to the region's water regime as a whole. At present, the water resources of the region are being used by all states of Central Asia. The annual water intake is 80-100 km^3. The general water consumption falls to the share of arable agriculture. Constructed water facilities, including 94 water reservoirs, 24,000 km of channels, and 8,000 stations of vertical drainage, support the irrigation in a 7 million-hectare territory. With development of irrigation the portion of secondary or recycled waters increases. They are represented by amounts of collector-and-drainage waters and discharge of drainage from irrigated territories, manufacturing, agricultural, and communal-general waters. Collector-and-drainage and discharge of irrigated waters are presented annually on average by 42.7 km^3 (about 40 % of river drainage). 9 km^3 out of this amount is not going back to the river-beds, but is taken outside the irrigated areas and used for the supply of irrigated drainage (human-made) lakes and wetlands. In the desert areas, where transit waters, channels, and collectors are absent, the general sources of water are the underground waters and atmospheric moisture forming the ephemeral (recurrent) water reservoirs and water flow (water-streams). The total annual potential of underground water resources is estimated at 31.5 km^3, 12.98 km^3 of which are approved for use. The water supply in lakes and wetlands of the flat territories (without Aral Sea), according to information in 2000, is 65 km^3. The high changeability (unsteadiness) and long-term fluctuations of water resources elements, hydro-chemical regime, and water quality are typical for the Central Asian region. In the little water periods of the recent years, the flow of the Amu Darya and Syr Darya rivers has not reached the Aral Sea.

Impact on freshwater biodiversity

The biological diversity of the region reflects the region's various landscapes and ecological conditions, and is relatively high for this geographical zone. There are 2,500 species of bacteria and about 3,000 species of fungi. Also plants in Central Asia are diverse, including more than 8,000 species with about 6,000 species growing in the mountains and more than 3,000 growing within the plains. Diversity of invertebrates is extremely high – about 20,000 species, and vertebrates in the region include about 1,000 species (these include about 120 fish species, 15 amphibian species, 103 reptile species, about 600 bird species, and about 160 mammal species).

Intensive irrigation and agriculture underlies land use in Uzbekistan and Turkmenistan. Irrigation has dramatically changed the ecological situation in many regions, rendering the survival of many desert animals impossible under the new ecological conditions. Changes in the valleys of great plain rivers also have led to the decline of tugai forests that were cut down or degraded as a result of the decrease in water flow. Owing to these changes and to direct threats from human activities, the ranges of Bukhara Deer, a local endemic pheasant subspecies, and other inhabitants of river forests have shrunk. As a result of extensive hydrological construction, salinization, and dropping of the level of the Aral Sea, the native ichthyofauna became extinct and several species of molluscs and crustaceans are nearing extinction. Likewise, regulation of the great rivers' water flow, appearance of new water reservoirs, wide development of irrigation networks, industrial pollution of water areas, mountain mining and exploitation of upper reaches of rivers, and the influence of introduced species of fishes, all have negatively affected the existence of many species of the original

Fig. 5. Scheme of the Aral Sea basin and its boundaries.

ichthyofauna and malacofauna. Owing to changes in ecological conditions in the Aral Sea region, the wetlands in the deltas of the Amu Darya River have lost their richest avian diversity. The breeding habitats of Mute Swan, Dalmatian and Great White Pelicans, Pygmy Cormorant, and other threatened bird species have declined noticeably.

The Aral Sea and its biodiversity

The Aral Sea, which had once ranked fourth in size in the world, has been drying up for the last four decades. By the year 2002, the Aral Sea had lost 4/5 of its primary capacity, its surface area had decreased to less than 1/3 the original area, its water level had dropped to 22 m (Fig. 6), and the salinity of its water had increased by 6-12 times. Furthermore, the Aral Sea deviated some 100-150 km from its previous shores, leaving behind over 45,000 km^3 of former seabed that turned into salty desert. Over 100 million tons of salty dust are blown far from the Aral Sea by winds annually. In the years with little amount of water the flow of rivers does not reach the current sea shores. By the end of 2002, the Aral Sea had been divided into three water reservoirs: the "Small Sea" having a surface area of 3,000 km^2, a capacity (volume) of 20 km^3, and a salinity of 18-20 g/l; the eastern part of the "Large Sea" having a surface area of 9,150 km^2, a capacity (volume) of 29.5 km^3, and a salinity of 120 g/l; and the western part of the "Large Sea" having a surface area of 4,950 km^2, a capacity (volume) of 79.6 km^3, and a salinity of 80 g/l (Fig. 7).

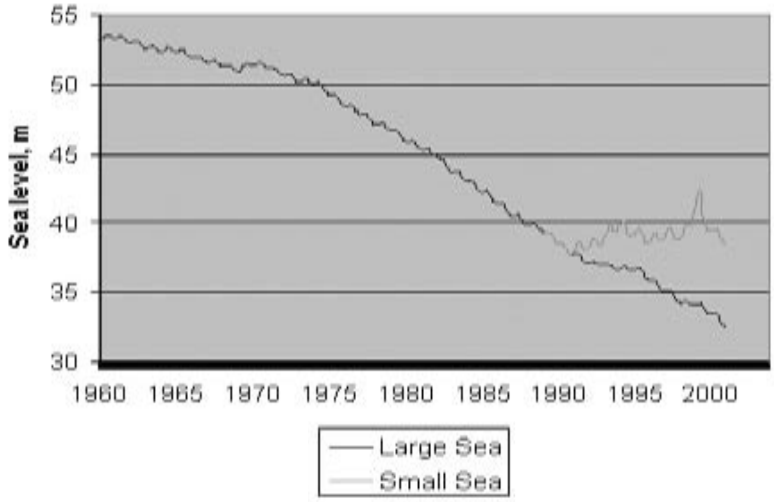

Fig. 6. Changing of Aral Sea level during 1950 - 2000.

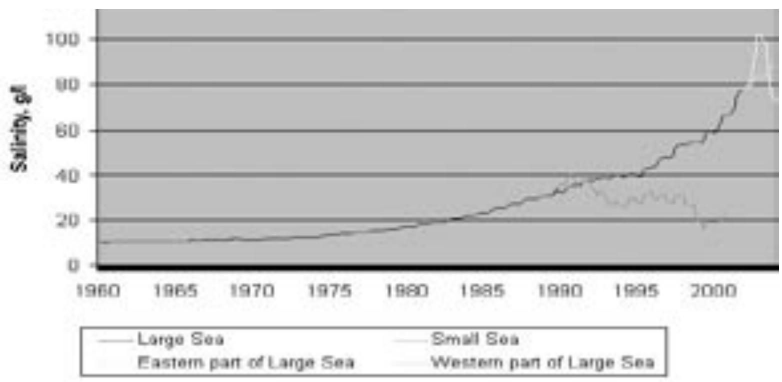

Fig. 7. Changes in the salinity of Large and Small Aral Seas during 1989-2001.

The inflow of the river waters in the deltas decreased about 5 times in the last 40 years. At the same time, the ratio of drainage waters increased. The average annual water discharge in the delta in the conditionally natural period was 1,060 – 2,090 m^3/sec. Between 1960 and 1970, these figures decreased to 850-1000 m^3/sec (excluding the extraordinary abundance in water in 1969, when the inflow to the delta was 2,090 m^3/sec). The lowest water supply was observed between 1980 and 1990 (Fig. 8). In the 1990s, the years of high water resources, water supply of the river flow into the delta increased by 10-15%. The change in the character of the Aral Sea configuration between 1964 and 2002 is presented in (Fig. 9).

Decrease of water supply considerably decreased the density of water reservoirs and wetlands and diminished their areas. By the middle of 1970, the majority of the lakes, supplied by river waters, dried up (Fig. 10).

Since 1980, work has been conducted on the supporting of irrigating-drainage lakes and on the creation of new water reservoirs, supplied by river and collector-drainage waters, in the recent delta and at the bottom of the Aral Sea. In the region of Shegekul Lake, the Mezhdurechenskoe water reservoir was built. Many breaks of dams and main bank have caused the flooding of the Dumalak Lake, forming the new ways for the flow of Amu-Darya River waters to the Aral Sea. The important direction of strategy is the work on restoration and rehabilitation of the Sudochie wetland. As a result of the conducted work, the summed area of the lakes reached 3,000 – 4,000 km^3 by

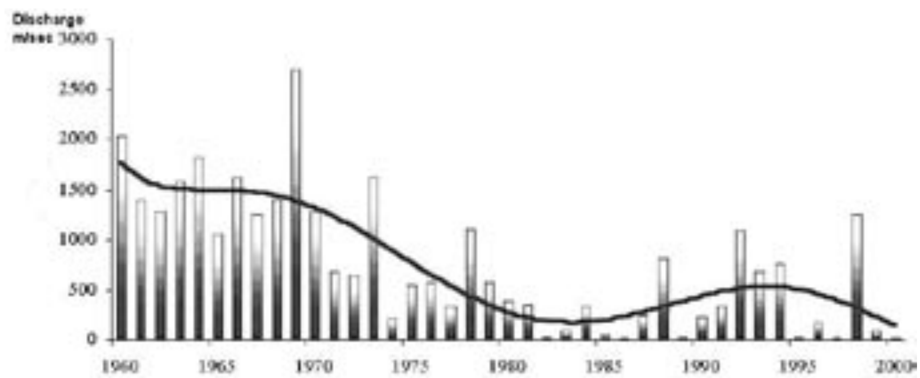

Fig. 8. Dynamics of in ow to delta of the Amu Darya River during 1960-2002.

1990. However, to date, the area of the delta has increased by 40%, and the sum of lakes covering has not reached its past figures.

Significant and impetuous changes to the hydrologic regime of the Aral Sea (speed, scale, and problems of transformation of the sea regime and environment followed this process) reflected on the ecological state of the whole region, particularly on the status and survival of plants and animals (Tables 5-8; Figs. 11-13). The Aral Sea lost its fishing value. Many species of flora and fauna disappeared or were depressed. This phenomenon requires the detailed quantitative assessment of its temporary states, analysis of ongoing processes, and estimation of influences on the environment of the region. The tremendous changes brought about to the Aral Sea ecosystem currently have no analogues, and only can be compared to the evolutionary transformation of the salty paleo-water-reservoirs. The current crisis of the Aral Sea ecosystem resulted in the extinction of fauna and flora which preceded the explosion of speciation in the geological past. Impact of the current regression of the Aral Sea on its fauna is similar to the impact of the regression of the marine and salty paleo-water-reservoirs on the conditions of the ancient marinelife. The current state of this sea allows the natural laboratory to observe the evolutionary processes within the separate taxa and the whole ecosystem. The universe character of the transformation permits discussing the current evolution of the Aral Sea ecosystem as a global biota evolution model.

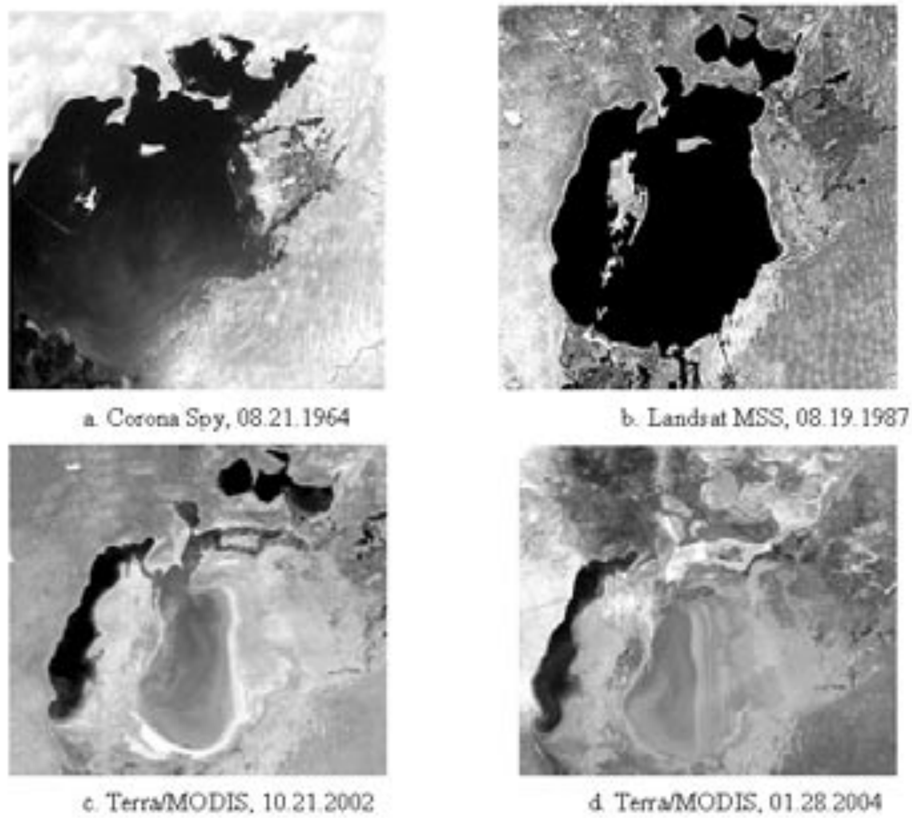

Fig. 9. Change of Aral Sea surface during 1964 – 2004 (a-d: satellite photo).

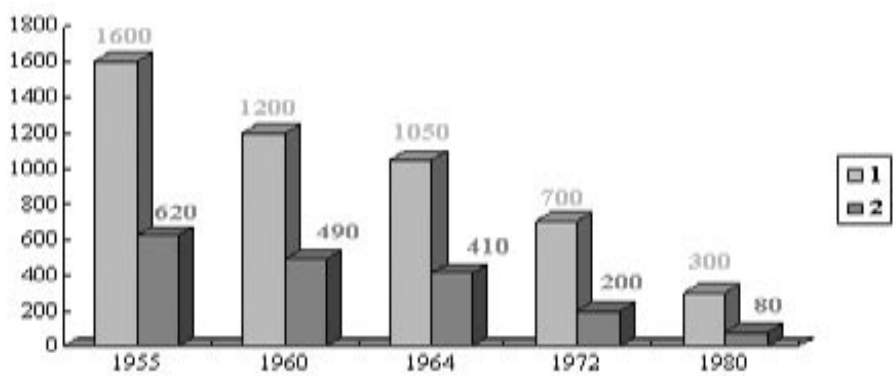

Fig. 10. Ratio of total square of river waters feed lakes in Amu Darya delta and water in ow to the delta top during 1955-1980: 1- water supply to the delta, m^3/sec; 2 - total square of lakes in delta, km^2.

Threatened biodiversity

Freshwater Biodiversity is affected and threatened by large-scale development and transformation of the inner water resources. At present, the Red Books of the Central Asian countries of the region list 30 species of fishes, 4 species of amphibians, 54 species of reptiles, 99 species of birds, and 79 species of mammals (Table 9). It is necessary to note that one of the main threats to the biodiversity of the region is the transformation of water ecosystems (besides the direct persecution of animals), which has led to the loss of unique ecosystems in the region, such as the gallery river forests ("tugai") with their original fauna and flora. Some animals were lost as a result of direct and indirect human influences, habitat loss, and deterioration. For example, in 1954, the last Caspian Tiger was killed in the "tugai" forest in Amu Darya River near Nukus town in Uzbekistan. This subspecies of tigers has disappeared not only because of the direct human persecution, but also, and perhaps mostly, as a result of the destruction of the gallery river forest and the drying up of reedbed areas along the Amu Darya and Syr Darya rivers. The Bukhara Deer is another large mammal occurring in the gallery river forests of Central Asia that is nearing extinction; it was saved through special conservation measures, breeding "ex-situ"

Table 5. Depletion of the taxonomic structure of the phytoplankton in the Aral Sea

Taxon/ Year	1925	1967-1974	1999-2002
CYANOPHYTA	41	79	30
BACILLARIOPHYTA	210	104	115
PYRRHOPHYTA	15	28	3
EUGLENOPHYTA	-	3	2
CHLOROPHYTA	109	60	9
Total number of species	375	306	159

Note: data for 1925 after Kiselev (1927); data for 1967-1974 after Pichkily (1981).

Table 6. Species composition of the zooplankton in the Aral Sea

Taxon/ Year	1971	1981	1989	1994	1996	1998	1999	2000	2001	2002
Hexarthra spp.	+	+	+	–	–	+	+	+	+	–
Synchaeta sp.	+	+	+	+	+	–	–	–	–	–
Nereis diversicolor	+	+	+	+	+	+	+	+	–	–
Cerastoderma isthmicum	+	+	+	+	+	+	+	+	–	–
Syndosmya segmentum	+	+	+	+	+	+	+	+	+	–
Chironomus salinarius	+	+	+	+	+	+	+	+	+	+
Moina salina	+	–	+	–	+	+	+	+	–	–
Podonevadne camptonyx	+	+	+	–	–	–	–	–	–	–
Halicyclops rotundipes	+	+	+	+	+	–	–	–	–	–
Cletocamptus retrogressus	+	+	+	+	+	+	+	+	+	+
Halectinosoma abrau	+	+	+	+	+	–	–	–	–	–
Calanipeda aquaedulcis	+	+	+	+	+	–	–	–	–	–
Artemia parthenogenetica	–	–	–	–	–	+	–	+	+	+
Number of species	42	18	12	9	9	8	7	8	5	4
Salinity, ppt	12	18	30	37	44	54	56	58-63	63-68	69-74

Note: data for 1972-1980 partly omitted.

Table 7. Species composition of the zoobenthos in the Aral Sea

Taxon/ Year	1950	1970	1980	1990	1995	1999	2000	2001	2002
Nereis diversicolor	–	+	+	+	+	+	+	+	–
Syndosmya segmentum	–	+	+	+	+	+	+	+	+
Cerastoderma ishtmicum	+	+	+	+	+	+	+	+	–
Caspiohydrobia spp.	+	+	+	+	–	–	–	–	–
Cyprideis torosa	+	+	+	+	+	+	+	+	+
Paleomon elegans	–	+	+	+	+	–	–	–	–
Rhithropanopeus harrisii	–	+	+	+	+	–	–	–	–
Turkogammarus aralensis	+	+	+		–	–	–	–	–
Chironomus salinarius	+	+	+	+	+	+	+	+	+
Number of species	60	67	32	14	7	5	5	5	3
Salinity, ppt	10	12	17	30	42	56	58-63	63-68	69-74

Note: data for 1950-1980 after Andreev et al. (1992); data for 1990 after Filippov (1996).

(in captivity) and reintroduction in appropriate places. The irrigation process and the taking of water from rivers for this purpose as well as the pollution and mineralization of waters have led to the loss and decline of the biodiversity of the wetlands and water ecosystems. First of all, the biodiversity of the Aral Sea was affected; from the 34 fish species of the original fauna, not many have survived to the present day. In general, water reservoirs of the Aral Sea basin lost a significant part of their original fish fauna: some fish taxa became extinct – Aral Sturgeon, Aral Trout, Chu Sharpray, Turkestan Dace, Kessler's Loach - and others are nearing extinction – Syr Darya and Amu Darya Dwarf Sturgeons, Pike Asp, Brachycephal Barbel, Ili Marinka, etc.
The assessment conducted in the framework of INTAS regional project 99-1483 "Correlates of the extinction risk for Central Asian biodiversity" using IUCN Categories and Criteria (version 3.1) (2001) showed that 63 fish species from about 120 species presented in the current fauna are threatened and that the Aral Trout subspecies became globally extinct. These are mostly species of the Caspian and Aral seas. However, many original endemic mountain species have been affected by pollution, competition with invasive species, and changes of environment. From the 15 amphibian species, 6 species are threatened; the Iranian Long-legged Wood Frog has disappeared from the region. Furthermore, 29 bird species related to water are threatened. The unique breeding places in the region of the Aral Sea and the deltas of the Amu Darya and Syr Darya rivers are, particularly, threatened, and the Scalybellied green woodpecker is a regionally extinct species. As for mammal species, 7 species related to freshwater ecosystems are threatened, 2 of which are extinct: the Caspian Tiger is a globally extinct subspecies, and the European Mink is regionally extinct as a result of the competition with the introduced American Mink.

Invertebrates also have been affected considerably, basically as a result of transformation and loss of ecosystems; several invertebrate species seem to be globally extinct. Thus, the large-scale transformation of freshwater ecosystems has led to the loss and decline of species.

Table 8. Ichthyofauna of the western part of the Aral Sea

Species/ Years	1990	1995	1998	2000	2001	2002	2003
Atherina boyeri	+	+	+	+	+	+	–
Platichthys esus	+	+	+	+	+	–	–
Clupea harengus membras	+	+	+	+	–	–	–
Neogobius uviatilis	+	+	+	–	–	–	–
Knipowitschia caucasica	+	+	+	–	–	–	–

Table 9. Threatened taxa in the Red Books and Red Lists of Central Asian countries

Taxonomic groups\ countries & official sources	KZ Red Book, 1996; Red List, 1999	KG Red List, 1985	TJ Red Book, 1988	TM Red Book, 1999	UZ Red Books, 1998, 2003
Fishes	16	1	4	13	18
Amphibians	3	0	0	1	0
Reptiles	10	3	21	22	16
Birds	56	20	37	41	51
Mammals	40	13	42	30	24
Invertebrates	96	5	58	45	80
Fungi	-	-	4	-	-
Plants	100	65	222	109	301
Total:	321	107	388	261	490

Influence of introduced species on the native biodiversity and their role in local economy

The human economic activity in the twentieth century became a powerful factor in changing the environment. The anthropogenic influence on the change of wildlife in the Aral Sea region was significant. As a result of the introduction of 16 invertebrate species and 22 fish species into this sea, its fauna was changed radically. Acclimatization of commercially sold fish and incidental acclimatization of some hydrobionts in the first half of the twentieth century undermined the food base of the local native fish species and decreased the commercial catch of fish. Constant decreasing of rivers flow and salinization of the Aral Sea has led to the unsuitability of the Aral Sea as a habitat for most of the local, native and introduced invertebrate and vertebrate species.

On the one hand, the introduced species affected the status of native original biodiversity, and many local species declined or were displaced due to the expansion of the introduced species. For example, the introduction of the American Mink has changed the status of the native European Mink (in Kazakhstan) and Eurasian Otter (in other countries of the region). On the other hand, some of the introduced species, such as Muskrat and Nutria, occupied free ecological niches and currently play an important role in local economies. The Muskrat species was introduced intentionally for its valuable fur; the Nutria species, however, acclimatized accidentally, escaping from the captivity of fur farms. Many intentionally- and accidentally- introduced fish species play an important role in fishery, successfully occupying the secondary water reservoirs (Grass Carp, Carp Bream, White Amur Bream, Prussian Carp, Silver Carp, Bighead Carp, Peled, Rainbow trout, Sevan Trout, Amur Snakehead, and Flounder). Some of the introduced species are used in the biological control of malaria-transmitting mosquitoes (Eastern mosquitofish). On the other hand, some accidentally-introduced fish species cause decline in the population size of several endemic fish species in the region, such as Chatkal Bullhead, Turkestan Sculpin, Turkestan Catfish, Aral Ninespine Stickleback, Turkestan Ide, Tashkent Riffle Bleak, Pike Asp, Turkestan Barbel, and Sharpray.

As the practice has shown, it is necessary to assess more carefully the impact of introduced and acclimatized species on the native wildlife, evaluating negative and positive influences and taking into account the regulating measures for the support of the original flora and fauna to achieve a state of balance.

The preliminary analysis of this situation has shown clearly the necessity, in the management of water ecosystem resources, to evaluate their productivity, carrying capacity, and acceptable bounds of their use. The implementation of special legislative regulations is enough to support the survival of some species (many hunting game species: ducks, gray geese, pheasant, muskrat, fishes, etc.). For other species, particularly the currently threatened ones, it is necessary to provide special conservation measures, monitoring, and proper management.

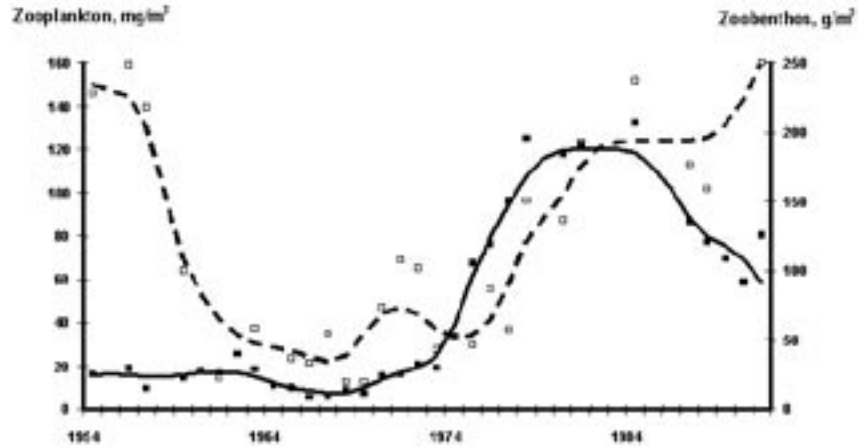

Fig. 11. Changes of zoo-benthos (firm line) and zoo-plankton (dotted line) in Aral Sea during 1954 -1991.

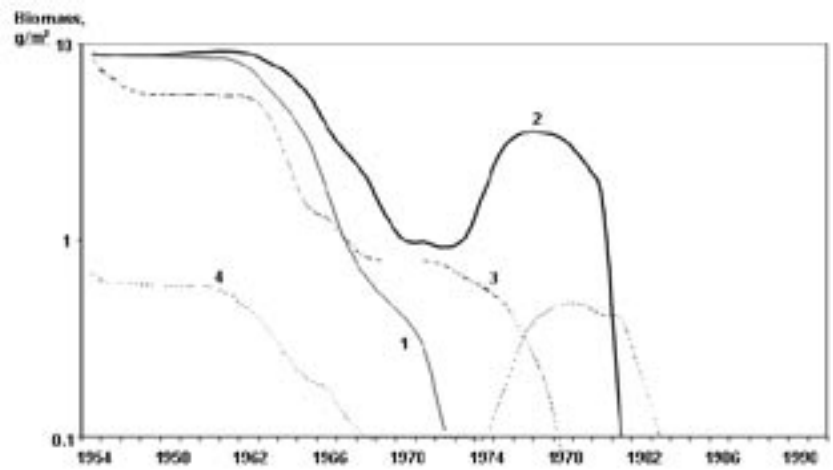

Fig.12. Changes in biomasses of some freshwater and brekish species of zoobetos in Aral Sea during1954 -1991: 1 - Chironomidae; 2 - Dreissena spp.; 3 - Hypanis spp.; 4 - Theodoxus pallasi.

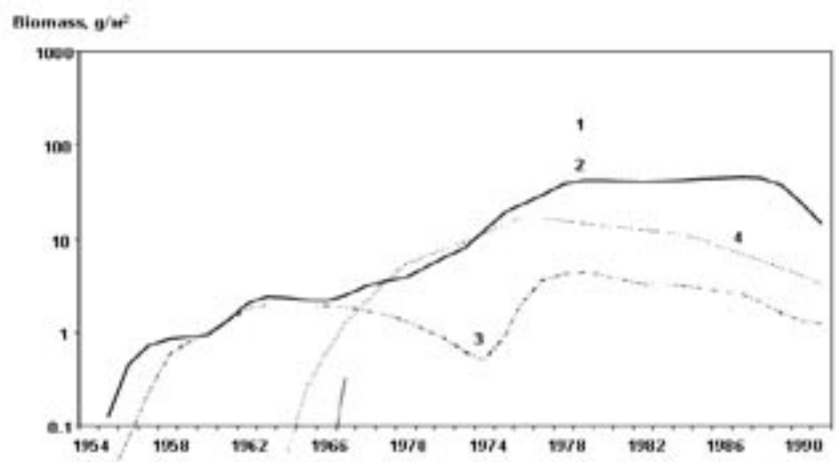

Fig.13. Changes of biomass of aboriginal and acclimatized euryhaline species of the Aral Sea zoobenthos during 1954 -1991: 1-Syndosmya segmentum; 2-Cerastoderma isthmicum; 3 -Caspiohydrobia spp., 4- Nereis diversicolor

Change in the productivity of the desert pastures under human and climatic factors

Change in climate as a result of the decrease in the Aral Sea surface area and the loss of the sea's thermal capacity is highly evident, although not so considerable. Influence of the sea-level drop on the thermal regime of the near-land (near-earth) layer of atmosphere is limited by coastal zone to 120-150 km. This is approximately the territory which is cleared from water or where the climate regime is affected by changes in deltas or level of subsoil (underground) water bedding. With the retreat of the Aral

Table 10. Protected Areas system in Central Asia

Categories of PA Countries	KZ	KG	TJ	TM	UZ
Strict Nature Reserves	9	6	4	9	9
National Parks	7	6	2	-	2
Nature Reservations	2	-	-	2	1
Sanctuaries (Zakazniks)	57	71	16	6	10
Nature Monuments	79	-	-	17	4
Total area (km²):	135,385	7,773	26,202	19,783	23,243
Percentage of country area:	0.3%	3.9%	18.3%	4.02%	5.2%

Sea, the humidity of air near the land surface also has decreased. According to observations of the Aral Sea Station, the average monthly air humidity decreased during development of irrigation activity from 42% to 30 %, i.e. a reduction of 12%. The change in humidity also has been registered in the Syr Darya River delta and in the Southern Aral Sea region, where it applies to a huge area and extends to the higher layers of atmosphere. Contents of moisture in 1.5 km layer of atmosphere decreased and provoked displacement of zone of convective nebulosity formation and influence of breeze winds. Owing to secondary effects and feedback, the influence of the sea on the climate of the boundary layer of atmosphere is of a bigger scale than on the near-land layer.

It is evident that the new salty desert named Aralkum is the destabilizing factor influencing the state of ecosystems and surrounding areas because the processes of salty desertification became stronger owing to the transfer of salts from the dry seabed. The special long-term observations conducted within the arid lands of Kyzylkum desert have shown changes in the productivity of arid pastures due to human activity (overgrazing) and climate change. To prevent and stop the degradation of the pasture areas and to optimize these areas, it is necessary to provide special measures, such as afforestation and recovering of grass on the dried-up bottom of the Aral Sea, rehabilitation of wetlands in the Aral Sea region, and creation of regulated wetlands around human settlements. Some measures on the solution of this problem are undertaken in the National Plan for the combating of desertification in Uzbekistan. In particular, this Plan considers the special program on the phytomelioration of pastures.

Species translocation

Under the negative circumstance influencing the ecological conditions of freshwater ecosystems in Central Asia, many species shifted to zones with appropriate conditions. This particularly has affected the migratory species, such as birds. Today, we can state that the distribution of many waterfowls and other water-birds has changed significantly. On the one hand, the disappearing of wetlands in the region of the Aral Sea has led to the loss of breeding habitats and important migratory stop-over places in the region. On the other hand, the new secondary wetlands have created similar conditions for the migratory flows and birds, new breeding, migratory, and wintering sites. The climate change and the observed warming, especially in the winter season, provide the appropriate conditions for the enlargement of wintering zone and for the forming of new wintering sites in the regions that used to be fully deserts. All other wildlife (fauna and flora) also have been influenced by existent changes and responded by adaptation to new ecological conditions. The poor fauna and flora of the traditional desert regions were fortified by new elements. In this process the leading role is the easy adaptive species play.

Conservation of biodiversity and protected areas covered freshwater ecosystems

The system of protected areas in the region includes various types of PA according to IUCN classification (Table 10). The core role in the conservation of biodiversity belongs to the strict protected areas (nature reserves and national parks, categories I and II of IUCN, respectively).

In spite of the rather good representation of different categories of protected areas, only part of them covers the biodiversity within freshwater ecosystems. For example, in Uzbekistan, there are 3 strict nature reserves out of 9 established in the zone of gallery river riparian forests (or tugai forests) – Badai-Tugai, Kyzylkum, and Zeravshan; in Turkmenistan, there is one only, the Amu Darya nature reserve; and in Tajikistan, there is also one, Tiger Gulli. The special strict protection of lakes and wetlands in Kazakhstan is realized in the Kurgaldjin, Naurzum, and Markakol nature reserves, and in Kyrgyzstan, in the Sary-Chelek and Issyk-Kul nature reserves. The wetlands are formally protected also by the system of special sanctuaries or "zakazniks" (category IV of IUCN), but the real protection and monitoring of wildlife within this category of protected areas are absent. Therefore, it is necessary to analyze the current system of existing protected areas within the wetlands and determine the gaps. Secondly, it is essential to elaborate the national, provincial, and local management plans for the governing of biological resources within the wetlands. But, it is necessary to note that all protected areas play a very important role in the conservation of freshwater biodiversity, because, for example, the mountain nature reserves and sanctuaries secure the protection of all freshwater streams and currents with their specific wildlife.

In the region, the legislative base for the conservation of freshwater biodiversity is presented as the system of national regulations and quotas on the using of biodiversity. The hunting regulations consider the questions of terms and rates for the hunting bag and fishery within the countries. The hunting terms should be revised each year on the base of regular census or survey of hunting game resources. In the region, the system of monitoring for the freshwater resources existed in the past. The permanent monitoring of water quantity and quality is conducted in all countries of the region, the monitoring of wildlife is carried out on the base of existed protected areas network (strict nature reserves) and within hunting management. Today, this system works only partially, especially in the area of wildlife monitoring.

Promise of Freshwater Biodiversity Conservation in Central Asia

Analyzing all the processes going in the region we can suspect now the relative stabilization of freshwater biodiversity in new ecological conditions. However, it is necessary to keep in mind several scenarios for the future use of water resources. The main task directly concerned with freshwater biodiversity sustainability is the value of so called "unused water reserves". These are not used for the purposes of agricultural or industrial development, or for public or drinking purposes, and are a basic ecosystem component for the survival of regional wildlife. From 1960, the value of such unused water reserves decreased more than 7 times (Fig. 14).

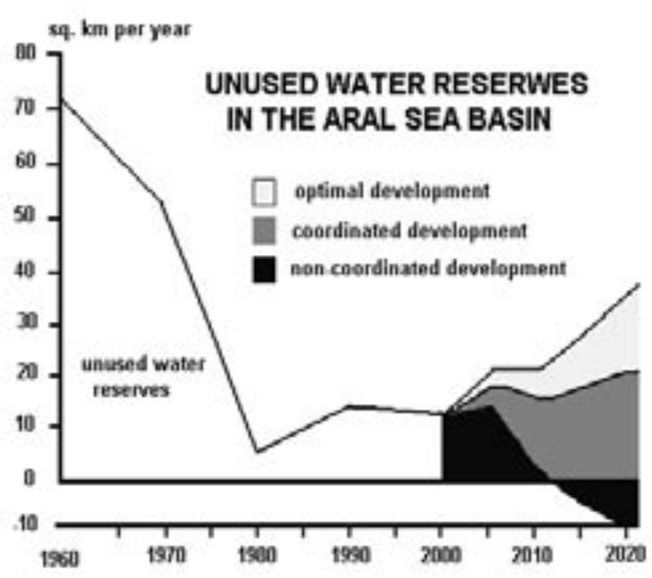

Fig. 14. Unused water reserves in the Aral Sea Basin

Actions on improvement of environmental and socio-economic situation in the Aral Sea Basin for the period of 2003-2010

The ecological crisis and the bad socio-economic situation in the Aral Sea basin are recognized by the world community to be among the greatest catastrophes of the twentieth century. Aiming at improving the conditions of the Aral Sea basin, the Heads of the Central Asian Governments created, in year 1993, the International Fund for Saving the Aral Sea (IFAS). In October 2002, the Presidents of the Republics made a decision to launch a new program under IFAS. They stated basic directions and entrusted the executive committee of IFAS, together with ICWC and ICSD, with the task of developing the "Plan of Actions for the Period of 2003-2010 on Improvement of Environmental, Social and Economic Situation in the Aral Sea Basin", with the agreement of the governments of participating countries.

At the Dushanbe's (August 28, 2003, Tajikistan) meeting of State Leaders "The main directions of the program of concrete actions on improvement of environmental and socio-economic situation in the Aral Sea basin for a period of 2003-2010" have been approved. The proposals are listed below according to their priorities.

1. *Development of coordinated mechanisms on comprehensive management of water resources of the Aral Sea Basin;*
2. *Rehabilitation of hydro-economic facilities and improvement of use of water and land resources;*
3. *Improvement of systems on environment monitoring;*
4. *Program on combating natural disasters;*
5. *Program on assistance to the solution of regional social problems;*
6. *Strengthening of the material-technical and legal base of the interstate organizations;*
7. *Development and implementation of regional and national programs on actions of environment protection in zones of water flow formation. The conservation of mountain and foothill ecosystems and glaciers is a priority objective. In this context, a study of factors that have dynamic effects on decreasing mountain glaciers and on the degradation of mountain ecosystems will be carried out. Also developing actions on reducing the negative influences of these factors will be taken into consideration.*

Generally, it is clear, that future status of freshwater biodiversity in the Central Asia region directly depends on the value of unused water reserves. It is expected that the current situation is cloase to the Coordinated Development Scenario. For example, in 2003 more than 17 km^3 of freshwater reached the Aral Sea, the most threatened water ecosystem in the region; after 40 years of the diminishing of the sea level, this process is under control today. Moreover, the new coordinated decisions approved by the governments of the Central Asian states lead to the conclusion that there are realistic promise for the sustainable use of water resources and freshwater biodiversity conservation.

Acknowledgements

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Water Scarcity in the WESCANA Region: Threat to or Prospect of Peace?

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This paper aims to present a new perspective of water scarcity in the WESCANA (West/Central Asia and North Africa) region in the era of globalization. It intends to introduce the concept of regionalism to achieve integrated water/environmental management. Linkages between water, food, and trade are of crucial significance to achieve "water-energy-food" security.

The paper intends to present three major shifts in thinking about water in the WESCANA region. These include ecosystem management of water resources at a regional level, the realization of virtual water (water embedded in food) in the regional water balance, and the notion of "green water" versus "blue water". Strategies and priorities for research in water management are addressed.

Introduction

The regional entity WESCANA (West/Central Asia and North Africa) was introduced by IUCN (IUCN - The World Conservation Union) to identify a region of the world comprising 24 countries. The water resources in these countries are characterized by scarcity, variability, and sharing. However, the region shares, to a great extent, common social norms, values, and local knowledge that help in adopting the notion of sustainable development.

The main issues and constraints relating to water management in WESCANA are the expansion of agriculture, urbanization, and demographic growth. These factors have led to a dramatic increase in water use, over-exploitation of groundwater, and deterioration of water quality. Besides, poverty, unequal land distribution, and disruption of traditional farming methods have led to desertification. Consequently, many initiatives relating to water management have been developed by many external funding agencies like UNDP/GEF (United Nations Development Programme / Global Environment Facility), World Bank, GTZ (German Technical Cooperation Agency), CIDA (Canadian International Development Agency), and USAID (United States Agency for International Development). In addition, there are also several regional initiatives that focus on trans-boundary water management, technology transfer, and awareness.

In fact, several of the main global water management initiatives, such as Global Water Partnership and World Water Vision, have focused their activities in the Mediterranean context. Few initiatives have been developed involving the Fertile Crescent countries or the Gulf countries. Therefore, much effort is needed to better link the global water initiatives and institutions to issues and activities within the WESCANA region.

The critical review of the global-local agendas reveals two major gaps in integrated water management. These include lack of systematic and coordinated approaches in dealing with water management, and lack of appropriate connections with global water initiatives and institutions. The experience of the last three decades, as formulated in the Mar Del Plata Action Plan (1977), Dublin Principles, and Agenda 21 emphasized the need for integrated water management. All these initiatives call for a comprehensive vision of the water sector including both sanitation and irrigation (Solanes & Gonzales-Villarreal, 1999; Al-Jayyousi, 2001; and Al-Jayyousi, 2002).

Population growth in the WESCANA region raises the prospect of greatly increased food-import needs. However, poverty levels raise doubts about the ability of the region to import enough grain to fill their food gaps. It should be noted that water scarcity is evident at the national level in most countries in the region. Specifically, the Middle East and North Africa (MENA) region is very dependant on both global and regional waters. It is likely that it will be more dependent on global water in the future. By the late 1980s, the global trading system in cereals enabled as much water (40 km^3) to enter the MENA region annually as that flowing down the Nile into Egyptian agriculture each year. This implies that about 20% of the region's water needs were being delivered to the region as "virtual water", i.e. water embedded in water-intensive commodities such as wheat.

The WESCANA hydrological system is becoming less able to meet the rising water demand. Food imports are important indicators of water deficit. Meanwhile, the global hydrological system is in surplus and is able to meet the global water demand for food. The linkages between water, food, and trade are global in character, and hence, must be viewed and resolved within a global framework combined with regional and national water policies and plans of actions. The conventional way for assessing water situations normally is based on a national or country level. This limited view does not take into consideration regional and global interactions in terms of water transfer (whether it is "blue" or "green" water) through trade in the form of food imports.

The reason for rethinking the conventional way (water balance per country) of water management is the emergence of a global economy. The crucial challenge for water professionals in the future is how to induce a paradigm shift in the conventional modes of water sector planning to new modes of thinking that take into account the globe and/or the region as a unit of analysis rather than the nation-state. At a regional level, there is a need to establish synergies between water, food, and trade to achieve water and food security. The WESCANA region represents a critical mass and a logical unit of analysis for water assessment and management. Complementarities among nation-states in water, food, and trade represent comparative advantages and economies of scale for each nation-state. Ecological and political borders rarely coincide. Few serious environmental problems can be solved within the framework of the nation-state. Some problems are bilateral, some are global, and quite a few are regional. The latter are often related to water: coastal waters, rivers, and groundwater. The fact that regional management programs exist and persist, in spite of nationalist rivalries, shows the imperative need for environmental cooperation.

Research Question

A fundamental question that this paper aims to address is: Is there enough water in the WESCANA region?

It is argued that at the global level, all means of subsistence (water, food, and energy) are in abundance. The perceived water crisis is a matter of allocations and distribution. It is interesting to note that all water balances and calculations of water deficits are on a national basis (each country is treated as a separate entity). No regional assessments of water balances were conducted to combine the dynamics of the three interconnected components, i.e. water, food, and trade. Hence, any strategic effort to view, think, and implement sustainable water strategies in the WESCANA region, should consider the following:

a) Water is an economic good, which should be allocated to its best use based on technical, economic, and environmental criteria. Water balances should be assessed with a broader context, such as an ecosystem, river basin, or watershed area. Assessment should consider the interactions between "blue" and "green" water.

b) Food security must be viewed and assessed in both regional and global frameworks by linking water, food, and trade policies.

c) Global trade of cereals, fruit, and vegetables represents a form of virtual water that alleviates water shortages at the national level.

Situation Analysis: Pressure - Response Analysis

In light of the IUCN vision for water and nature, IUCN envisions the WESCANA region as one where 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. Also, it is a region 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. It is a world where ecosystems are managed and used in a fair and equitable manner for economic security. This will include economic valuation of water resources

Environmental degradation inevitably leads to a decline in social and economic security. 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 form the point of departure for changing the ways that we manage water resources in the future. The human-water-nature interactions may be depicted in a pressure-impact-response model of water resources degradation as outlined below.

Important drivers and a description of pressure-impact-response for water/environmental issues reveal the following:

- The unsustainable rise in population and booming economic growth have led to increased natural resource consumption, social inequity, and poverty.
- Increases in the demand for water resources impose pressure on 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 region's ecosystems. Wetlands and aquatic habitats have disappeared, and the quantity and quality of many surface- and ground-water systems are 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 the changes or adapt to them, or neglect them altogether.

Global Ranking	Country	Water per Capita/Year (cubic meters)	Global Ranking	Country	Water per Capita/ Year (cubic meters)
108	Iraq	3,287	165	Oman	388
114	Pakistan	2,961	168	Yemen	223
129	Sudan	2,074	169	Bahrain	181
131	Iran	1,955	170	Jordan	179
141	Syria	1,622	173	Saudi Arabia	118
149	Lebanon	1,261	174	Libya	113
155	Morocco	971	176	Qatar	94
156	Egypt	859	178	UAE	58
162	Tunisia	482	179	Gaza Strip	52
163	Algeria	478	180	Kuwait	10

These drivers, pressures, states, impacts, and responses provide us with a conceptual basis for unraveling the complex linkages between societal behavior and either degradation or conservation of freshwater resources.

There are finite limits to the capacity of the earth's freshwater and related ecosystems 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.

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 manage water resources in a sustainable manner.

The augmenting pressure of increasing water demand and resulting conflicts, together with the greater variability in and uncertainty of global environmental and hydro-climatological 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.

Biodiversity and environmental protection require the establishment of interdisciplinary, inter-sectoral, and inter-institutional projects - both large and small - that develop strategies in a holistic way, building primarily on the needs of the catchment inhabitants. This 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.

Pressure

It is widely recognized that the Middle East and North Africa (MENA) region is by far the driest and most water scarce region in the world. This issue is increasingly affecting the economic and social development of most countries of the region. MENA has 5% of the world's population with less than 1% of the world's available freshwater resources.

For most countries in the Middle East, water is the limiting resource for development. Iran, Iraq, Lebanon, and Sudan, are fairly well endowed with water; the three Maghreb countries (Morocco, Algeria, and Tunisia) and Egypt form a middle group; and Jordan, Libya, and countries of the Arabian Peninsula are the least endowed.

Today, average per capita water availability in the region is about 1,200 cubic meters per year (world average is close to 7,000). The annual water availability in the region ranges from about 1,800 cubic meters per person in Iran to less than 200 cubic meters per person in Jordan, West Bank/Gaza, and Yemen.

In March 2003, the World Water Assessment Report published by UNESCO painted a grim picture of the state of water resources in the WESCANA countries. The following table presents the average per capita water availability for countries in WESC

All countries in the Middle East and North Africa region are classified as arid or semiarid. By 2025, the amount of water available per person in Africa and the Middle East will drop by 80% in a single lifetime (from 3,430 cubic meters to 667 cubic meters).

The following table represents major issues of sustainable water management in two subregions in WESCANA: North Africa and the northern Arabian Peninsula.

Issue	North Africa	Northern Arabian Peninsula
Level of exploitation of water resources and trends	High level of exploitation and over-abstraction of groundwater leading to saltwater intrusion. Major deficits of drinking water supply in rural areas.	High level of over exploitation of groundwater due to severe shortage of rainfall in many areas. High seasonal and annual variations.
Role of Agriculture	Important contributor to GDP in most countries. Provides high levels of employment. Expansion of irrigated areas is on the agenda.	Small to moderate role of agriculture in the region's GDP, but agriculture is the main consumer of water. Significant water losses in agriculture.
Water quality and ecosystems	Deterioration of water quality is evident.	Decreasing quality of water as a result of industrial discharges and insufficient water treatment mechanisms. Problem of salinization of surface water. Insufficient water monitoring.
Water demand measures	Not widely applied. Constraints in the implementation of price schemes.	Water conservation pricing structures, promotion of water saving technologies, and other water demand management measures are being implemented or are on the agenda of some countries.
Desalination and wastewater	A small contribution to total water supply. Desalination is being used in Tunisia, Egypt, and Libya.	Wastewater reuse implemented in the subregion. Potential of wastewater reuse increased.
Institutions and legal systems	The institutional legal framework for IWRM is in place in many countries. Need for effective enforcement of the laws and regulations.	Many are involved in planning, regulation, and delivery in many countries. Need to reinforce regulatory functions and enforcement of standards.
Reallocation Issues	Water savings in agriculture could be reallocated.	Water savings use for reallocation of water. No permanent water rights.

Source: Global Water Partnership: Water for the 21st Century: Vision for Action- Framework for Action for the Mediterranean

Conceptual framework

The relationship between water, food, and trade may be illustrated in a triangle of Water, Food, and Trade. This simple model depicts the interdependence between water and food security. Moreover, it illustrates the basic fact that arid countries resort to the import of food to overcome water deficit. In other words, water deficits at a national level were alleviated or managed by economic solutions through global trade.

Hence, in any strategic effort to view, think, and implement sustainable water strategies in the Arab world we should consider the following:

a. Water is an economic good that should be allocated to its best use based on technical, economic, and environmental criteria. Water balances should be assessed in a broader context, such as a river basin or watershed area within a region, not a nation-state.

b. Food security must be viewed and assessed in both regional and global frameworks.

c. Some arid countries utilized trade of cereals, fruit, and vegetables, which represents a form of virtual water.

Paradigm shifts in water management

A paradigm is defined as a mental model, a way of seeing things, or a conceptual framework. However, a paradigm may enhance patterned modes of thinking. This patterned thinking constrains creative modes of thinking. A shift in paradigm may be needed if the existing paradigm fails to address certain problems. A well-known paradigm shift in basic sciences took place when classical physics was replaced by modern physics. Water is an interdisciplinary field, which covers a wide array of fields, such as basic sciences, engineering, law, history, and socio-economics. In order to induce a paradigm shift in water strategies in the Arab world, we have to rethink and reconsider the conventional ways in which water is viewed, valued, and managed. Three relevant dimensions are addressed below. These include: the domain of estimating water balance, region versus nation-state; the distinction between "blue" and "green" water; and the notion of "virtual water".

Region versus nation-state

The extent of water issues in the WESCANA region is normally defined and expressed at the nation-state level. However, the issue when viewed from regional and global contexts seems to offer new perspectives. The following is an argument for the "value" and "significance" of "regionalism". WESCANA as a "region" represents a critical mass and a logical unit of analysis for water assessment and management compared to a nation-state. Complementarities among nation-states in water, food, and trade represent comparative advantages and economies of scale for each nation-state.

The following are seven arguments in favor of a more comprehensive development of regionalism as presented by Acharya (1992):

Although the question of national territory size might be less important in a highly interdependent world, regional cooperation is imperative, particularly in the case of micro states, like the Arab world, which either have to cooperate to solve common problems or become client states of the "core countries" (the "sufficient size" argument). Self-reliance, which is rarely viable at the national level, may be a feasible development strategy at the regional level, if defined as coordination of production, improvement of infrastructure, and making use of complementarities (the "viable economy" argument). Economic policies may remain more stable and consistent if underpinned by regional arrangements, which cannot be broken by a participant country without provoking some sanctions from the others (the "credibility" argument). Collective bargaining at the level of the region could improve the economic position of marginalized countries in the world system, or protect the structural position and market access of emerging export countries (the "effective articulation" argument).

Regionalism can reinforce societal viability by including social security issues and an element of redistribution (by regional funds or specialized banks) in the regionalist project (the "social stability" argument). Ecological and political borders rarely coincide. Few serious environmental problems can be solved within the framework of the nation-state. Some problems are bilateral, some are global, and quite a few are regional. The latter are often related to water: coastal waters, rivers, and groundwater. The fact that regional management programs exist and persist, in spite of nationalist rivalries, shows the imperative need for environmental cooperation (the "resource management" argument). Regional conflict resolution, if successful and durable, eliminates distorted investment patterns, since the "security fund" (military expenditures) can be tapped for more productive use (the "peace dividend" argument). In sum, development regionalism contains the traditional arguments for regional cooperation, such as territorial size and economies of scale, but more significantly, adds other arguments that express new concerns about and uncertainties of the climate change and its impact on water resources.

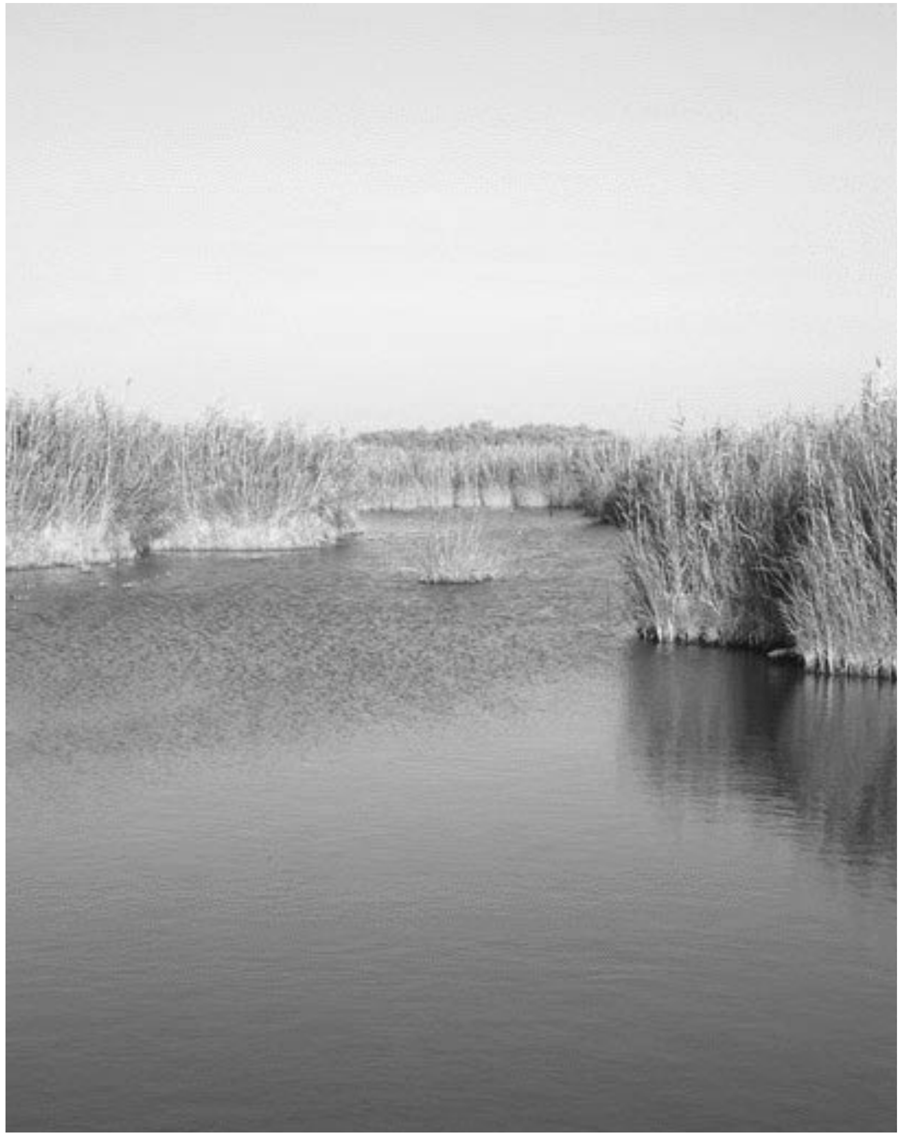
In his work on the making of regions through security discourses, Bilgin (1997) argues that parallel to globalization is another process at work, that of regionalization. It is often argued that peoples of a globalizing world, in search of some degree of control over their external environments, have started taking action within their own milieu in cooperation with other actors sharing similar problems.

Regionalization, in this sense, is seen as an attempt to come to terms with the forces of globalization. Regionalization and globalization then may be viewed as two mutually reinforcing processes.

Blue versus green water

Conventional water resources assessments project severe physical water scarcity problems affecting 30% of the world's population over the next generation. Such conclusions are based on a supply-demand analysis comparing what is generally called "freshwater availability" with "freshwater withdrawals". Availability of freshwater (at a country, regional, or global level) is taken as the assessed and accessible flow of stable and perennial surface and subsurface runoff in lakes, rivers, and groundwater. This water is defined as "blue" water flow (Falkenmark, 1995), as distinguished from "green" water flow, which is the remaining proportion of the terrestrial hydrological cycle, namely the return flow of vapor to the atmosphere as evapotranspiration. It has been estimated that realistically we can access some 12,500 Gm^3/year of blue water flow, out of a cumulative average of 38,000 Gm^3/yr of runoff flow (Postel et al., 1996). This corresponds to 11% of the annual precipitation over land surfaces (approximately 110,000 Gm^3/yr). Vapor flow over terrestrial areas accounts for 64% of the annual precipitation over land areas.

The following discussion is based on the work of Rockström (1999 & 2000). Global "freshwater withdrawals" are normally estimated at some 4,000 Gm^3/yr (year 2000) (e.g. Shiklomanov, 2000). These human withdrawals are used to cover water needs in industry (accounting for 23% of the withdrawals), household and municipal use (accounting for 8%), and agricultural use (accounting for 69%). It is when such data on blue water availability (at a country, regional, or global scale) is compared with direct water withdrawals at present and in the future, that severe regional water scarcity projections evolve. The forecast for 2025 is a global withdrawal of 5,200 Gm^3/yr (Shiklomanov, 2000). The increased withdrawal is a direct result of population growth and socio-economic development. The reason for this can be stated quite simply: all we do requires water in one way or another, and the more we do and aspire to do, e.g. when economic development permits it, the more water per capita we demand. As freshwater resources are finite (they also are sensitive, being under constant threat of human induced deterioration), we seem to be heading toward an unavoidable crisis. For every newborn human being, pressure on water will increase. At present, we are withdrawing one third of the estimated "water ceiling" (12,500 Gm^3/yr); how will the situation be with 2 billion newborns in 30 years time, especially in dry regions with the most rapid population growth? Regional and local implications of human pressure on scarce water resources already can be seen. These include over-extraction of river base flow for irrigation and industrial use (e.g. the Colorado river), rapidly falling groundwater levels due to over-extraction (e.g. semiarid parts of India), and large scale ecological collapse due to hydro-engineering (e.g. the Aral sea).



All these cases of serious, often even catastrophic, implications of over-extraction of blue water are very worrying. However, the question is if they are the first signs of a creeping global crisis or rather isolated hot-spots in areas where mismanagement, scarcity, and human pressures coincide. In an attempt to look into this question, it is relevant to step behind the assumptions used in water resource projections. Human pressure on freshwater resources has been expressed in several different ways, with the basic common feature that human demand for water is the key driver behind increased freshwater withdrawals.

This pressure generally is expressed at country, regional, or basin level, in the form of stress indices, such as the ratio between water withdrawal or water demand and water availability. For projections into the future, withdrawals or demand are based on estimates of projected human freshwater demand, which, in turn, are based on estimates of human freshwater requirements. These vary between assessments and range in the order of 1,200 - 1,700 m^3/cap/ yr. Water stress indices generally are based on this annual per capita flow, where a country with a freshwater availability lower than 1,700 m^3/cap/yr is considered to be under stress (based on Falkenmark's water stress index) (Falkenmark, 1986). This estimated annual per capita need can be divided into pure blue water uses, equal to direct use of liquid blue water flow, for drinking and household purposes, municipal purposes, and industrial purposes. The global per capita average needs to cover direct blue uses amounts to about 190 m^3/cap/yr, which corresponds to a global withdrawal of 1,100 Gm^3/yr (Shiklomanov, 2000). The remaining 90% of per capita water requirement is for food. This is explained by the fact that food production is by far the world's largest economic water-consuming sector, with approximately 1,500 m^3/cap/yr required to produce an adequate diet.

Whether or not mankind is heading towards a global water crisis is, therefore, foremost a question of whether there is enough freshwater to sustain food production (if, still according to the conventional view, we focus only on direct human needs for water in industry, municipalities, and agriculture). In a broadened view, if we also include indirect use of freshwater to sustain ecosystems, the water crisis challenge also requires that we address the need for an institutional, policy, and ethical environment at hand to deal with water trade offs to sustain different water-using sectors (i.e. to manage water conflicts been rural-urban needs, and economic biomass growth versus ecological biomass growth).

Let us concentrate on conventional assessments for the moment, based on direct water uses. The first critical conclusion is that drinking water supply, sanitation, and industrial water requirements are not, and will never become, an issue of global water resources scarcity, even though, in certain arid locations, societies experience scarcity of blue water for direct blue water uses. Low percentages of populations connected to water supply systems and often poor household water quality are rarely issues of water scarcity, but are issues of poor water management. Even a world's population of 10 billion people will never claim more than about 2,000 Gm^3/yr, which is less than 20% of realistically accessible runoff water and only about 2% of global precipitation over land areas. If we add the promising developments in desalinization technologies, where the price for desalinization is moving well below 1 USD/m^3 of water, then human blue water demands seem even more "under control".

This means that, for conventional water resource assessments, the most dominant driver by far that actually pushes mankind towards the ceiling of freshwater availability is water for food. The question, though, is whether or not it is analytically correct to carry out water resources predictions by comparing freshwater availability in terms of country level access of blue water flow with human water requirement in terms of a general per capita index of which 90 % is water for food.

Such a bias towards blue water flow (the blue water branch in the hydrological cycle is considered equal with the freshwater resource) would be justifiable if, and only if, the world's largest water using actors, namely farmers, tapped their productive water to produce food from perennial and monitored blue water sources.

In order to shed some light on the issue, an analysis has been carried out on the predominant source of water, either rainfall returning directly as green water flow in rain-fed agriculture or runoff blue flow in irrigated agriculture, which at present is used to feed the world's population. Data on blue water withdrawals in irrigation are taken from IWMI (2000) as well as data on areas under rain-fed agriculture and estimated grain yields in irrigated and rain-fed farming systems. The green water withdrawals have been calculated assuming global water use efficiency in rain-fed grain production of 3,000 m^3/t grain (evapotranspiration flow). Analysis reveals that in some countries direct return flow of vapor from rain-fed agriculture accounts for over 80% of water withdrawals for food production (dark green), while some countries have a green water dependence of 60 - 80 % (green). There are also some countries that depend to over 80% on blue water withdrawals in conventional irrigation systems (dark blue) and countries that depend on a blue water range of 60 - 80 % (blue). Some countries have a blend of green and blue water dependence (a green water range of 40 - 60 %) (diagonal lines).

It can be shown that water in the world is largely green, with 70% of the countries depending primarily on green water flow (return flow of vapor in rain-fed agriculture) to sustain food grain production. This is still a strongly conservative estimate, as the highly green water dependent livestock sector is not included in the calculation. As will be seen below, there is strong evidence to suggest that the green water used to sustain permanent grazing for livestock is larger than the green water used in grain production, which would increase direct green water dependence.

The conclusion is that conventional freshwater assessments compare apples with pears, i.e. blue water availability with a general human water requirement index (the 1700 m^3/cap/yr) that for the largest part, in most countries of the world, is covered by direct return flow of vapor in rain-fed agriculture, rather than by blue water withdrawals.

The above points to the fact that we actually do not know how much water, or even what form of water (green or blue), is needed to sustain present global food production, or will be needed to sustain future production. It is true that we humans may need about 1,700 m^3/cap/yr to cover our water needs. However, both in most temperate North European countries and in tropical developing countries, only about 190 m^3/cap/yr are actually blue. The water resource sustaining food production originates from rain where it falls and returns as vapor, but is never taken into consideration in water resources assessments. No country in the world has projected per capita blue water availability below 200 m^3/cap/yr, which is the volume threshold under which direct blue water uses could be threatened.

So far the analysis seems to support three statements. First, there is little or no evidence to support the projections of a creeping physical global water crisis. We can conclude that the water crisis is a symptom of inequity and poverty. The disastrous examples of widespread water scarcity affecting 1 billion world inhabitants are primarily a result of mismanagement, rather than physical scarcity per se. Second, the analysis suggests that more attention has to be given to green water dynamics, as a majority of the per capita water requirements are fulfilled from direct return flow of green water in rain-fed agriculture. Here, another form of water scarcity is in focus, namely recurrent droughts and dry spells caused by unreliable tropical rainfall. Third, it remains essential to conclude that physical blue water scarcity remains a reality and a future risk, for the dry semiarid and arid regions of North Africa, the Middle East, and parts of South and East Asia, where irrigation plays a dominant role in securing local livelihoods.

Real versus virtual water

Another shift of thinking is needed in terms of water assessment. The water budget per country only includes surface water, groundwater, and treated wastewater. However, water embedded in food, which is referred to as "virtual water", is not taken into account.

The concept of virtual water as proposed by Allan (2000) reflects the level of the interdependencies between the global and the local policies in water management. The production of every ton of a food commodity such as wheat requires a water input of about 1000 m^3. The trend in cereal imports reflects a reasonable approximation of the capacity of an economy to meet its strategic food needs. The change in water and agricultural policies in major countries like Egypt and Saudi Arabia is evidence of the role of virtual water. For example, Egypt changed its subsidies policies in 1986, which had favored cotton, so that wheat production became a sound financial option for its farmers. Also, by 1986, Saudi Arabia's irrigation projects had begun to produce sufficient wheat for most of its needs, and it was about to become a significant wheat exporter in the world market. Later, Saudi Arabia reduced its wheat production because it was unsustainable to use fossil water.

Water scarcity is evident at the national level in most of the WESCANA region. However, most water is being consumed for producing food. Food production consumes about 90% of a community's water. Since 1970, the constraint for socio-economic development of the Middle East was lack of sufficient water.

As a result, water was imported in the form of food. In practice, more water flows into the Middle East each year in this "virtual form", embedded in cereal imports, as is used for annual crop production in Egypt. Usually, regional and global markets can provide food through trade to alleviate the problem of insufficient water for food from certain nation-states. McCalla (1997) argued that global players, especially in the water intense food sector, could provide solutions to local water resource deficits via virtual water in the water, food, and trade nexus.

Water for peace: Necessary conditions

In order to operationalize the notion of water for peace for shared water resources, the following conditions must be met:

1. Hydro-solidarity through dialogue (communicative action)

Dialogue among policy makers plays a vital role in building trust and confidence among riparian states. Non-distorted communication is necessary to develop mutual understanding. A communicative action may be evaluated on the basis of four validity claims. These include: the statement is true, right, honest, and comprehensible. Institutionalized public participation, like water parliament, plays a vital role in building trust, transparency, and peaceful agreement in shared water management.

2. Institutional/legal imperative

Political and institutional theory developed a framework to address common pool problems. In other words, common problems require three things:

1) Institutions which ground benefit and costs of the actors involved.
2) Regulations, which govern the actors' behavior.
3) Norms and recognition of legitimacy, which allow institutions and regulations to function.

Once a competitive common pool situation develops, users relying upon a basic decision rule of willing consent and following the economic principles will be led to accelerate their competitive race with one another for the limited supply. Individual users may be led to adopt any or all of the following patterns of conduct:

1) To conceal or minimize resource to essential information.
2) To ignore adverse effects on the resource in the conduct of their own enterprise.
3) To follow a hold-out strategy in relation to other parties drawing upon the same resource pool.

Traditionally, four theories governing the use of international rivers exist in literature. These include:

1) Harmon Doctrine, which advocates absolute sovereignty to upper riparian states.
2) Absolute Territorial Integrity, which guarantees to the lower riparian the use of the river in an unaltered state.
3) Drainage Basin Development or the Community Theory, which stresses mutual development of a river's waters by all riparian states.
4) The Restricted Territorial Sovereignty or Equitable Utilization Theory, which permits use of a river's waters to the extent of doing no harm to other riparian countries. The last theory has become the most widely advocated by the international legal community.

Conclusions

To achieve sustainable water management within a river basin, there is a need for a linkage between international law principles and hydrological considerations. A regional institutional framework and a water parliament should be developed to serve as a platform for facilitation, mediation, and conflict resolution for shared water resources. Other conditions are viewed as "necessary" for the conceptual framework to be workable and viable. These include:

- Availability and access to water-related information.
- Improved communications among policy makers in the water sector.

Operationalizing the international law principles is essential to define criteria (or equity standards) for equitable and reasonable allocation of shared water resources. The study recommends the establishment of a regional institutional framework as a forum for sharing data, group decision making, collaborative problem solving, and building consensus among riparian states.

It is realized that resource professionals need to develop and use new approaches to planning and management, which incorporate local values and worldviews more effectively than they had in the past. Such approaches should combine the strengths of transactive planning with the rational comprehensive tradition. Public participation is vital to ensure sustainability and equity. At the global level, the water vision for the WESCANA region should combine water-related sectors. It also should be based on participatory approach. Specifically, the following measures should be considered:

1) Increasing desalinated water production, where feasible, in order to reduce dependence on groundwater and improve its quality.
2) Adopting a demand management policy that would curb excessive consumption by implementing a leak detection/reduction and system renewal program, metering all water services and applying progressive water tariffs, enforcing water pumping regulations, and implementing a public education program.
3) Reforming the agricultural sector by expanding the use of treated wastewater for irrigation, promoting efficient irrigation systems, reconsidering crop pattern, considering the application of a tariff on groundwater used for irrigation, and regulating abstraction from private groundwater wells.

A shift of thinking is needed in the new era of global economy. Instead of adopting the saying “Think global, act local”, we need to adhere to a motto of “Globalize consciousness, regionalize vision, and localize benefits”. People-centered development must be adopted as a model for achieving sustainable development. Regional vision for water in Arab countries may provide a new way to look at the water crisis in the region.

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