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Increasing returns on investment opportunities by applying a nexus approach

Best practice nexus case studies

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Executive summary

To showcase how increased returns on investment opportunities can be achieved by applying a nexus approach, best practices of the Water-Energy-Food (WEF) Nexus were collected in the form of several case studies within the frame of the Central Asia Nexus Dialogue Project. The best practice cases focus on water, energy and food security dimensions that advance socio-economic development and propose the nexus as a promising approach to resolving competition over limited resources.

The selected case studies cover a range of WEF security concerns for a variety of key stakeholders linked with these sectors and are assessed through a Stakeholder-Problem typology that summarises challenges across the Central Asian region. Apart from lessons learned, each case study includes an explanation of its relevance to the region.

This collection of case studies support a better understanding of the WEF Nexus approach and thus allows for the shortcomings of single sector approaches to be addressed. The selected case studies provide insights from other regions of the world and offer important lessons learnt that support the Central Asian region in designing interventions and planning for investments that help achieve WEF security. However, the case studies do not produce a comprehensive catalogue of methods, tools and approaches. Every nexus intervention needs to be designed and planned within the specific context and supplemented by concrete awareness raising and targeted capacity building.

The case studies include examples of multi-purpose infrastructure, which offer a convincing way forward, where social and environmental externalities are better integrated into design and investment and benefits of investments are shared across more than one sector. By learning about practical examples and applications of the WEF Nexus approach in other regions, the project stakeholders are encouraged to adapt the newly gained knowledge to the unique context of the Central Asian region and plan for multi-purpose investments as well as consider linkages and synergies between water, energy and food sectors.

The selected case studies were used to develop a number of possible future scenarios for Central Asia, which are aligned along two key axes: (i) the extent to which institutions are strengthened and mandated to adopt a more transboundary approach; and (ii) the extent to which planning remains trapped in silos or has been redirected onto a more multi-purpose, multi-sector basis. Scenarios are a powerful way to raise awareness of likely outcomes of different courses of action, or indeed of non-action.

In the context of Central Asia, to mainstream the WEF Nexus approach, the following will be essential:

I. At the **national level**, WEF Nexus perspectives need to be strengthened and incorporated into national policies, strategies and plans; capacities and bottom-up approaches need to be increased and local solutions to regional nexus problems sought.

II. At the **regional level**, it will be necessary to develop regional development objectives through dialogue and negotiation, share benefits across the entire Aral Sea Basin and strengthen regulatory frameworks for joint decision-making.

The scenarios further indicate where vertical linkages between the national and regional levels are possible to support the Central Asian region in its efforts to apply nexus approaches to address issues of WEF security.

By learning from case studies, relevant institutions, public and private sectors have the opportunity to advance their understanding of the cause and effect relationships as they execute their mandates and implement policy actions and reforms.

Acronyms and abbreviations

BMZ	German Federal Ministry of Economic Cooperation and Development
CAREC	Regional Environmental Centre for Central Asia
EC IFAS	Executive Committee of the International Fund for Saving the Aral Sea
EU	European Union
IUCN	International Union for Conservation of Nature
IWRM	Integrated Water Resources Management
MSIOA	Multi-Sector Investment Opportunity Analysis
OMVS	Organisation pour la Mise en Valeur du fleuve Sénégal (Senegal River Basin Development Authority)
SMEs	Small- and Medium Enterprises
WEF	Water-Energy-Food
WISE-UP	Project: Water Infrastructure Solutions from Ecosystem Services Underpinning Climate Resilience Policies and Programmes
ZRB	Zambia River Basin

1. Introduction

1.1 What is the 'WEF Nexus' approach?

Human existence depends on the availability of water, food and energy. These sectors are often governed and managed in isolation despite the fact that the use of and actions taken in one resource impact one or both of the others. The Water-Energy-Food (WEF) Nexus has emerged as a way forward to provide options to mitigate stress on water resources posed by climate change, increasing population, economic development and urbanisation. Water is becoming increasingly scarce in relation to the demands upon it and the requirements for water are changing as economies diversify. At the same time, finance for much needed infrastructure is becoming increasingly more difficult to secure given the economic demands for more growth and development. Only a small amount of available funding is allocated for multi-purpose infrastructure (EIB, 2016 Budapest Water Summit). Multi-purpose infrastructure offers a convincing way forward, where social and environmental externalities are better integrated into infrastructure design and investment, and where more than one sector benefits from the investment. However, investments remain constrained by a combination of factors, which include the following:

- Sectoral silo thinking on the part of policy makers and planners, often driven by institutional mandates, legal limitations and the often silo nature of conventional finance;
- Inflexibility in development interventions and finance – often limited by well-meaning and solid experience in sectoral development approaches, but not cross-sectorally focused;
- Government policies, which favour for example food self-sufficiency over food security, and consequently raise issues of sovereignty, which can challenge transboundary cooperation and the nexus through limiting cooperation and supply chains for example; and
- An unwillingness to accept trade-offs or compromises that could speak to a greater and longer-term set of benefits, often limited by short-term political horizons and self-sufficiency concerns.

Better understanding the WEF Nexus can support addressing the dilemma of single sector approaches and foster understanding of linkages between natural resource use, allows for the brokering of compromise, trade-offs or synergies between competing interests.

Although its seeds first appeared at the Mar Del Plata Conference in 1977 where delegates concluded that *"good water management must be part of broader governance and government at all scales*, *not a self-contained silo into which other parties are invited on sufferance",* the 'nexus' grew on mainly academic thinking to identify and address trade-offs through the 2000's. The Bonn Nexus Conference in 2011 is seen by some as a landmark event, where broader political and commercial interest in the nexus was raised and the 6th World Water Forum in 2012 greatly influenced the discourse on the nexus amongst the different actors. The World Economic Forum and the Rio Conference have rigorously promoted the WEF Nexus, which is regarded as an ideal mechanism for better management of the three sectors to achieve water, energy and food security. However, for many, the nexus is still a new and untested idea.

The nexus is not a one-way discussion. Nexus thinking challenges the application of historical and local knowledge and highlights the need for greater integration of core elements of resource management and sectoral development, such as data collection, sharing and analysis/interpretation (Ozment et al, 2015). Through dialogue, opportunities can be created to bring together people with a variety of experiences from across sectors, to brainstorm and exchange knowledge, with the ultimate aim to move to developing and implementing practical actions. This is based on the belief that there is a competitive advantage for all institutions, public, private, etc., to better understand the cause and effect relationships they are involved in through both implementation of their mandates, and policy actions and reform. The increasing pressures on water resources mean that relying on 'safeguards' to protect social and environmental integrity are often not good enough. Through better identification of risks, sharing the risks and optimising the trade-offs that need to be made between sectors, advantages for all sectors can emerge.

The three nexus opportunities can be defined as follows:

- ***Trade-offs,*** whereby a preferred objective is traded for another, which may be absolute or seasonal (for example hydropower storage and release of water for energy generation at different times of the year);
- ***Compromises,*** whereby a result, which is less than perfect for one or more stakeholders is accepted by all; and
- ***Synergies,*** where one intervention covers multiple nexus objectives and as such would be the way that a "win-win-win" can be achieved (e.g. an example might be natural infrastructure, such as a manufactured wetland that increases the supply of water for crop and energy production, while contributing to biodiversity and improving water quality and so could be invested in and managed by all benefitting sectors).

The WEF Nexus approach focuses on considering and engaging the agricultural and energy sectors to ensure the recognition of impact, sharing of data, investment opportunities and trade-off identification to understand where development synergies can be identified. This becomes even more important in transboundary situations, such as is the case in Central Asia, where energy is traded across borders and rivers may be affected by energy generation due to hydropower storage. This reconciliation of different water needs and uses is important to:

- Look beyond the basin, at appropriate scales of resource use to identify where investment is needed, where management improvements are required and where policy reform could be an option;
- Identify potential additional benefits from co-management and coordination over different resources as opportunities for cooperation (for example, between water and energy use, in particular hydropower operators); and
- Conduct (policy) focussed dialogue, building understanding and trust between stakeholders from different sectors that look to the future development of the resources and sectors they are responsible for.

Finally, by looking for multi-sector, multi-purpose investment options to enhance development, increase production and economic growth, considering the inter-linkages between the water, energy and food/land management sectors, the nexus is likely to:

- ***Reduce*** the pressure on line ministry budgets because investment costs are shared with others, as well as better risk identification and joint mitigation;

- ***Increase*** the economic returns on a given investment because of the multiple benefit streams that can result from multi-sectoral investments that focus on the multiplier effects on investment and improved management.

Box 1: WEF Nexus vs. IWRM

Due to historical confusion and challenge by some, it is necessary to explain why nexus is not the same as Integrated Water Resource Management (IWRM). There are several reasons why this is so:

- ***IWRM*** is concerned with the allocation of water between competing uses − this makes it highly technocratic in nature and it hence resides in the domain of water managers occluding broader but key issues of policy and political economy.
- ***IWRM*** does not address broader issues of resource and human security, for which different classes of stakeholders have different perceptions including for national governments, territorial or economic security.
- ***IWRM*** is limited to the watershed and as such has tighter boundaries (i.e. river basins), whereas nexus transcends hydrological boundaries, which might be sectoral, geopolitical, economic (such as supply chains, both public and private) or civil-administrative in nature.
- ***IWRM*** tends to be applied at the level of the basin or catchment, whereas nexus can be applied at any scale. IWRM has struggled to really get the impact across the economic, equity and environmental principles it is guided by and recent documented progress suggest IWRM remains off-track to achieve SDG 6.5.1 by 2030.

Because the concept of IWRM is based at the river basin management level, this can often disengage some of the more powerful water management sectors, such as agriculture and energy. Particularly the energy sector is often disengaged from the basin, where it extracts water from, or impacts downstream flow, leading to a disconnect in resource use to economic benefits and trade-offs that can occur.

Yurts in the Kazakhstan Mountains, Almatay © Shutterstock/Aureliy.

1.2 The Central Asia Nexus Dialogue Project

The Central Asia Nexus Dialogue Project is one of five regional projects that together comprise the global "Nexus Regional Dialogue Programme" funded by the European Union (EU) and the German Federal Ministry of Economic Cooperation and Development (BMZ).[1] The Programme intends to strengthen the political processes needed at the regional and national levels to meet the increasing demand for water, energy and food. To do so, it supports regional stakeholders in the development of concrete dialogue and policy recommendations and action plans for future 'nexus' investments, with specific emphasis on multi-sector infrastructure and corresponding capacity development activities.

In Central Asia, the regional nexus project is implemented by the Regional Environment Centre for Central Asia (CAREC), in partnership with the International Union for Conservation of Nature (IUCN) with the support of the Executive Committee of the International Fund for Saving the Aral Sea (EC IFAS). The Project's ultimate aim is *"to provide support to Central Asian countries in economic development and regional cooperation transformation required to meet increasing water, energy and food (WEF) security demands through the WEF Nexus approach."*

By drawing on and learning from experiences of other regions, key stakeholders are provided with the opportunity to better understand the nexus approach. By learning about practical examples and applications of the nexus in other regions, the project stakeholders are encouraged to adapt the newly gained knowledge to the unique context of the Central Asian region and plan for multi-purpose investments as well as consider linkages and synergies

[1] The other regions are Southern Africa, West Africa, Central America and the Middle East.

between water, energy and food sectors. This in turn can help to support social and environmental development across the region.

To this end, this document presents the nexus as a process, which takes place where competing interests of water, energy and food intersect and has been prepared for the Central Asia Nexus Dialogue Project. Using case studies and sharing lessons learned from different countries, regions and river basins, the document demonstrates that the nexus can be used to reconcile competing interests: water, land and energy, or water, food, energy and the environment, or even water, energy and navigation.

2. Best practice case studies

The case studies presented here suggest that the nexus offers a promising approach to the resolution of potential resource conflicts. At the same time, it also can expand development possibilities across the region in times of increasing competition over water, energy and food resources between stakeholders from climate change, increasing water needs and scarcity, population growth and economic diversification to promote growth and development.

2.1 Framework of analysis – typology of nexus relevance for Central Asia

To this end, the following case studies focus on water, energy and food security in the region for a variety of key stakeholders linked to these sectors and security concerns. Table 1 presents a Stakeholder-Problem typology, which helps to contextualise the relevance of the case studies. It summarises challenges across the Central Asian region in providing water, energy and food security (as introduced above) for four main stakeholder groups, i.e. state entities, civil society, private sector and the environment (including its services). The Stakeholder-Problem typology indicates a range of inter-sector, sometimes transboundary competition between the water, energy, food and environmental sectors. Accordingly, the selected case studies cover the full range of security concerns across the stakeholder groups and contextualise the relevance of the case studies for the Central Asian region. Each case study will be presented in brief and their relevance analysed according to the identified typology. The case studies describe the nexus challenges and how these have been or are being overcome. To this end, the case studies are numbered as follows:

① The Zambezi Basin: A multi-sector investment opportunity analysis;
② The Volta River Basin: Trade-off analysis for transboundary infrastructure investment planning;
③ Multiple sector use of irrigation infrastructure across Asia;
④ Nexus approach in the Senegal River Basin;
⑤ Agribusiness as natural infrastructure in the Southern African region;
⑥ The Rhine River Basin: multi-stakeholder cooperation;
⑦ Water Hyacinth control in Southern Africa: a multi benefits analysis;
⑧ Solving inefficient irrigation in Indonesia

Table 1: Stakeholder to Problem Typology

STAKEHOLDER	PERCEPTIONS OF RESOURCE SECURITY	REGIONAL PROBLEMS IDENTIFIED IN THE LITERATURE and DISCUSSIONS TO DATE:					
		a. water security		b. energy security		c. food security	
State Entities	economic growth	1	Glacial melt due to climate change leads to floods (& reduces medium to long term water supply) (1) (3)	1	Unreliable, inadequate energy supplies constrain economic growth; upstream dam releases affect downstream water use and availability (1)	1	Population growth and increasing food and nutritional security (1)
		2	Reduction in annually available water because available storage is inadequate with respect to the capture of water which is increasingly encountered as flood peaks rather than naturally attenuated flows (1) (3)			2	Low agricultural yields due to water supply and availability problems, ageing infrastructure, land health problems (soil nutrition, salinization, waterlogging etc) (1)
		3	Over-regulation of water flows in favour of hydropower for electricity generation (1) (2) (4)				
		4	Changing demand profiles due to economic diversification, changes in agricultural needs, domestic increase (1) (2)	2	Changing energy demand profiles due to economic diversification and population growth (1) (5)		
		5	Low water use efficiencies in agriculture (& network) (8)				
		6	Cross cutting problems due to poor institutional capacity, silo policy making and planning; vested interests and inadequate levels of political capital (6)				
	peace and stability	7	Competition for water contributing to regional tensions and potential instability (2) (4)				
Civil Society	water supply and sanitation	8	Limited access to water sector services				
		9	Polluted water (6)				
	reliable livelihoods	10	Competition for irrigation water in allocation, management, and system design failures (1) (2)	3	Inadequate and unreliable energy constrains the creation of expanded and diversified livelihoods and affects land health (1)	3	Agriculture is dominated by industrial crops, reducing access to water for irrigating food crops. Industrial crop diversification for biofuels and energy conversion not available (2)
				4	Improved irrigation technology usually requires increased, more reliable energy (1)	4	Shortage of new or rehabilitated irrigation facilities, exacerbated by: i) increasing infrastructural degradation; and ii) increasing aridity due to climate change
Private Sector	reliable factors of production	11	Water shortages for commercial irrigation and other industrial uses (1) (7)	5	Unreliable energy supply (1)		
Environment (and services)	sustainable habitats	12	Compromised environmental stream flows (2) (5)				
	sustainable ecosystem services	13	Glacial melt due to climate change compromising natural hydrographs (3)				
		14	Watershed degradation (erosion, invasive species) (5)				

Victoria Falls, Zambezi River, border Zimbabwe and Zambia ©Shutterstock/Eva Mont.

2.2 Case Study 1: A multi-sector investment opportunity analysis on the Zambezi Basin[2]

2.2.1 Description

The Zambezi River Basin (ZRB) is shared by eight riparian countries − Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia and Zimbabwe. The basin is one of the most diverse and valuable natural resources in Africa, which is critical to sustainable economic growth and poverty reduction in the region as it provides important environmental goods and services to the region and is essential to regional food security and hydropower production. Extreme climatic variability characterises the flows of the river and its tributaries and as a result, floods and droughts frequently devastate people and economies of the region, especially the poorest members of the population.

Unilateral, post-independence development and political economy strategies of the riparian countries, as well as the diverse physical characteristics of the Basin, have led to mainly unilateral management of the water resources. To illustrate the benefits of cooperation among the riparian countries in the Basin through a multi-sectoral economic evaluation of water resources development, management options and scenarios to increase agricultural yields, hydropower outputs and economic opportunities — from both national and basin-wide perspectives – a multi-sector investment opportunity analysis (MSIOA) was conducted by the World Bank (Alavian et al., 2010).

Using a total of 29 different scenarios, the analysis assessed the relative strengths and weaknesses of different combinations of investment concepts for hydropower, irrigation and

[2] Adapted from Riddell 2015

floodplain restoration in the river basins – with domestic water supply and environmental stream flows prioritised as unaffected benefits/options in almost every case. Focusing down on eight scenarios, they represent a very clear and helpful illustration of how trade-offs work between the three nexus elements: water, energy and food (Figure 1 below).

The figure illustrates changes in the production of one sector (energy) under a range of development scenarios, which include either no change or a single change in another sector, in this case irrigated area. The baseline **Scenario 0** shows a situation with an installed hydropower generation capacity of 22,776 GWh/year and an irrigated area of 260,000 ha. All demand for domestic water supply is satisfied; but although allowance is made for the restoration of natural flooding in the Lower Zambezi Delta, no other allowance is made for environmental in-stream flows.

In this manner, **Scenario 1** shows what happens if power generation is better coordinated (an increase of 7.1% in generating capacity). As with the baseline case, all demand for domestic water supply and for flood restoration in the lower delta are satisfied; but no allowance is made for environmental in-stream flows. **Scenario 2A** assumes that the existing development plans of the Southern African Power Pool are implemented, but with all demand for domestic water supply and flood restoration in the lower delta satisfied along with an allowance made for environmental in-stream flows. **Scenario 2D** is the same as Scenario 2A but with power generation fully coordinated throughout the transboundary basin. **Scenario 3** assumes no further investments in hydropower, which is produced under non-coordinated conditions, but the irrigation potential is exhausted and an additional area of 774,000 ha with all demand for domestic water supply and flood restoration in the lower delta satisfied along with an allowance made for environmental in-stream flows. It indicates a significant trade-off against power generation and for growth of the agricultural sector. However, the expanded irrigation service would create an additional 250,000 jobs, which is another trade-off, especially as new value chains[3] and improved livelihoods would likely increase demand for energy.

From the baseline scenario, the methodology allows to present other situations, of which the most preferable fall into what the World Bank calls the “desirable development zone”. These scenarios (5, 5A and 8) will be a nexus-oriented solution almost by definition as they are (i) aware of the impacts on different resource bases and sectoral needs and (ii) able to use scenarios as predictors of what is technically feasible and economically desirable. An important assumption of this methodology is that political will exists and the suggested scenarios are politically acceptable.

Scenario 5 illustrates an option to allow for an additional 774,000 ha of irrigated area while a portion of the investment in new power generation would be traded towards increased agricultural production and employment (likely containing increased energy demand of newly employed agricultural sector workers and the value chains they are employed in). **Scenario 5A** is the same as Scenario 5, except that power generation is coordinated across the transboundary basin.

Similarly, **Scenario 8** shows a situation where, compared to the baseline, both hydropower generation and irrigation area increases. The difference to Scenario 5 is that hydropower dams are used for flood protection, whereby they are operated at less than full supply level during flood seasons in order to provide unused storage for flood attenuation purposes. It can be assumed that the economic benefits of flood protection more than outweigh the economic costs accruing

[3] Some of which will produce waste material, which could be used for co-generation e.g., rice husks or bagasse (pulp waste following sugar cane extraction). Other agricultural waste, if composted, would reduce the need for energy intensive synthetic fertilisers, other waste still, could be used for biogas production etc.

to sub-optimal power generation (although avoided costs such as disaster prevention are harder to predict due to climate change uncertainties).

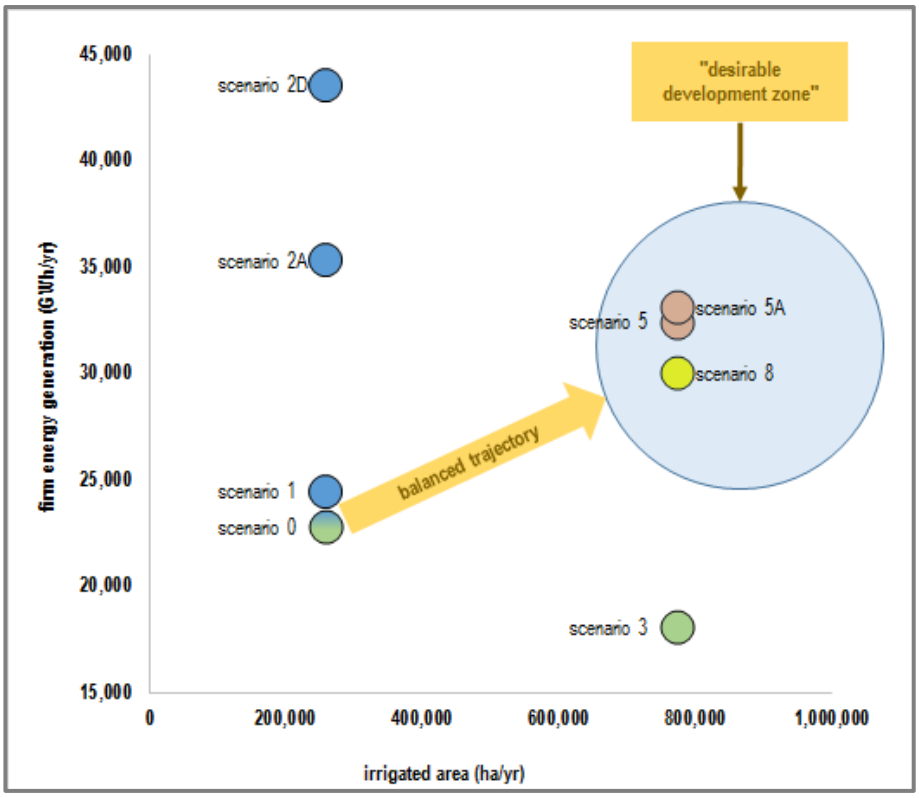

Figure 1: Potential for energy generation and irrigation by development potential in the Zambezi River Basin

2.2.2 Lessons learned

Three lessons emerge from this example:

- Nexus can be applied in an iterative fashion, testing various combinations of results using scenarios and multi-sector dialogues to test approaches using common and agreed data and objectives (shared vision approaches);
- Trade-offs can be applied at very large scales and so can be absorbed at scale and therefore mitigated against, provided this is recognised and understood; and
- Changes in the operational rules of hydropower dams can increase benefits in other sectors, in this case irrigation and flood control, but may therefore create challenges to secure energy generation during dry periods.This can create opportunities for other renewable energy investments (Opperman et al., 2019) that can help stimulate economic diversification, new business opportunities, low carbon development and access to investment and modular systems that put less strain on ageing transmission networks.

2.2.3 Relevance to the region

Although this case study presents potential scenarios, rather than an actual investment, it is highly relevant as it provides a common point of reference for all riparian countries. The complexities inherent in national economics and transboundary political relationships are not directly addressed in this analysis. Instead, this is left to the riparian countries to consider. The analysis

allows the countries to make informed decisions based on the results of this and other analyses that clearly show that significant contributions to water, energy and food security can be achieved by combinations of smartly sized and operated hydropower and expanded irrigation with additional flood management benefits. Most nexus research to date points to the need to better coordinate planning across sectors and in transboundary situations to minimise problems and maximise returns. In this case, this study was used to frame discussions amongst riparian states based on agreed data and science and capacity from the region to inform higher-level development discussions.

In the Central Asian region, a multi-sector investment opportunity analysis could act as a decision-support tool that enables better integration of investments in water management infrastructure into the broader economic development and growth objectives of the riparian countries and the Basin as a whole. It allows for trade-offs to be balanced and identified and further helps negotiation and decision-making processes. Referring to the Stakeholder-Problem typology, it can be seen that this approach would be relevant to some 13 of the 23 identified problem areas across water, energy and food security, specifically a.1/2/3/4/10 and 11; b.1/2/3/4 and 5; and c.1/2. (see ① in Table 1).

Akosombo Hydroelectric Dam, Volta River, West Africa ©Shutterstock/Sopotnicki.

2.3 Case Study 2: Nexus trade-off analysis in support of transboundary infrastructure investment planning in the Volta River Basin

2.3.1 Description

The Volta River Basin is one of the largest river systems in Africa, covering an area of approximately 400,000 km², spreading over six riparian West African countries (Benin, Burkina Faso, Côte d'Ivoire, Mali, Togo and Ghana). In the Upper East region of Ghana, benefits from natural infrastructure services provide communities from the Pwalugu region with an average annual income of US $1,360 per household (including base flow benefits across a population of up to 30,000 people). Natural seasonal flooding of the White Volta River supports a long standing and healthy flood recession agriculture economy, which in turn offers a range of livelihood activities that correspond to 53% of total annual household income. It also helps to fill seasonal freshwater depressions turning into breeding ponds that support fish farms as the floodwaters retreat. Flooding is also critical to recharge the groundwater on which people rely on for drinking water during the dry season. The river's annual hydrograph, i.e. alternating periods of river spate and base flow, drives a key part of the economic and social well-being of the population that has adapted to the flow of the river and who depends on the flooding for recession farming, floodplain cattle grazing and capture fisheries. These activities provide valuable incomes, support food security for villages close to the river and allow for trade across the region.

A multi-purpose dam (the Pwalugu dam) proposed for the White Volta River in Northern Ghana, close to its border with Burkina Faso, is intended to produce up to 200 Gwh/year. If built according to its original design, the dam would impact downstream river flow and reduce flood events

important for local food production, resulting in competition between hydropower, irrigation needs, and local livelihoods.

As part of IUCN's WISE-UP project[4], to support decision-making and better understand the impact of the possible operating modes and construction of the proposed dam on different livelihood activities, the value and benefits derived from the river basin were monetised. A basin model combining different sources of data (hydrological, infrastructure data etc.) was developed to visualise the trade-offs and different impacts the operation and design of the proposed Pwalugu dam could have on relevant natural systems. These data and information were shared with a range of stakeholders in Pwalugu, including the River Authority, the Irrigation Board, the Energy producers, key government institutions, civil society as well as local stakeholders. Through a series of Action Learning workshops stakeholders were encouraged to collectively deliberate on which trade-offs to prioritise, based on reliable information of the impacts on other sectors. The Pwalugu Dam Steering Committee, formed of various stakeholders from the agricultural, energy and water management sectors to inform the dam design and planning process also engaged with the IUCN project, as some of these Steering Committee members were invited to participate in the multi-stakeholder learning workshops.

Stakeholders were shown how to make informed choices over what priorities to include in the modelling process, and how decisions can be applied on which service(s) to optimise over others using the dam, natural system or combinations of the two as a set of 'hybrid solutions' (see Figure 2). The different coloured lines in Figure 2 represent different operation modes of the proposed dam (a to f) and indicate how the dam would perform under different scenarios for the five livelihood priorities. Scenarios, which are likely to perform better, appear at the top of the figure, where benefits are maximised across each priority. A flat horizontal line at the top of the figure would indicate ideal performance for all the priorities. The model shows that it is not possible to maximise both energy generation and agricultural production from recession farming. The different options driven by stakeholder needs can help balance the positive benefits between the different livelihood options and minimise the negative impacts from, in this case, the proposed Pwalugu dam.

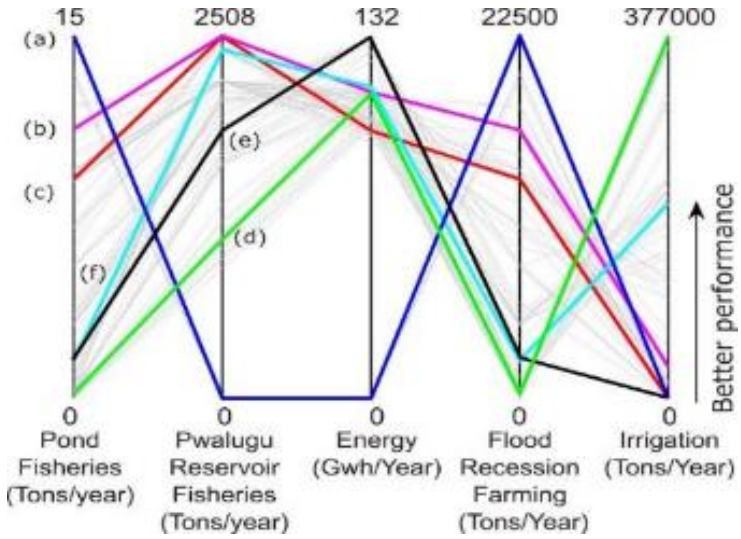

Figure 2: White Volta Basin Trade-off Possibilities

[4] 'Water Infrastructure Solutions from Ecosystem Services Underpinning Climate Resilient Policies and Programmes' www.waterandnature.org/initiatives/wise-climate

The power of this approach is that it allows decision makers and stakeholders affected by different development interventions to combine different options, such as maintaining some of the natural river flow for flooding and irrigation systems, including run-of-river irrigation diversions. This in turn, allows stakeholders to determine what is the best available blend of options, depending on their needs and wishes, the policy options that allow these developments, the current allocation regime for water resources and the economic returns from the different options. These tools can help identify where possible 'tipping points' exist, i.e. where the increases in one benefit relative to another are too extreme. For example, where energy generation may severely impact fish catch, or where energy generation may affect the generating capacity of downstream hydropower by looking at the broader hydraulic system. As such, quantifications developed using approaches like this provide important data for negotiation between different sectors and resource users.

2.3.2 Lessons learned

The results of the Pwalugu modelling exercise that was done collaboratively with multiple stakeholder groups demonstrates that trade-offs, compromise and even synergies can emerge from a nexus approach when multi-sectoral opportunities and impacts are assessed in detail. Indeed, early stakeholder engagement and the application of an iterative modelling approach, like the one done for the Pwalugu dam, can be crucial to find common ground and understanding as the basis of nexus negotiation.

In this real-life case, the dam has not been developed yet, because the marginal economic benefits of the potential energy production through the dam did not outweigh the downstream impacts on the environment and livelihoods of people. Instead, a formal irrigation scheme was introduced that was considered a more economically viable investment.

Other lessons learned include the following:

- Although modelling of this kind may result in controversial or unpopular recommendations, it is nonetheless a powerful tool for the quantification and visualisation of Water-Energy-Food interactions.
- Cross-sectoral cooperation and an understanding of political economy is critical during nexus dialogues to understand which institutions have the power to make decisions and the mandate to determine allocations of water resources. Often, it is the energy sector that has the legal mandate to do this and not the water or agricultural decision makers. These power dynamics and relationships were mapped and explored during repeated Action Learning consultation meetings. These consultations were designed to understand where the ‘room for manoeuvre’ existed between stakeholders in order to come to acceptable agreement, recognising the positive and negative impacts of, in this case, the proposed dam. Datasets and information need to be available for all stakeholder institutions involved to build understanding across sectors and stakeholders. Frequent consultations are needed to open up new areas for potential collaboration in decision-making, which can help to improve understanding.
- Understanding the implications (positive as well as negative) of trade-offs and compromise supports the identification of an optimal nexus solution. It is possible to overcome competition between sectors and conflicts over allocation of resources through the sharing of data and identification of opportunities for trade-offs and compromise.

2.3.3 Relevance to the region

The case study presented above elaborates the use of an analytical tool rather than an actual nexus investment. Nonetheless, it is relevant to the Central Asian region as it offers a tool to use real-life data and situations to illustrate the concrete impacts a proposed dam could have on a variety of livelihoods that depend on the natural resources. At the same time, the modelling demonstrates that significant contributions to water, energy and food security can be achieved by the adoption of multi-purpose operating rules at hydropower dams – acknowledging trade-offs, finding compromise and nourishing synergies. This is relevant to problems a.3/4/7/10 and 12 and c.3 (see ② in Table 1).

Fisherwoman in Boeung Chhmar Ramsar Site ©IUCN/Pheakdey Sorn.

2.4 Case Study 3: Multiple sector use of irrigation infrastructure from across Asia

2.4.1 Description

Various studies have shown that paddy fields can contribute to reducing flood risks. According to Sujono (2010), more than 40% of rainfall could be stored in paddy fields without compromising yields[5]. This approach has already been successfully introduced in parts of Thailand and is being considered for adoption in northern Malaysia. During periods of heavy rainfall, excess water is diverged to the paddy fields and the government pays compensation to the affected farmers. This option is cheaper than constructing a large flood control dam that may only be used every few years. In other words, this is a nexus style trade-off between rice yields in the flooded area and flood damage elsewhere. It is interesting to also understand that yields are often dependent on cropping calendars. The farmers consider planting rice at sub-optimal times in order for the fields to be empty during the period when floods are more likely. This is being tested in Vietnam's Mekong Delta (Khanh Triet et al., 2018). Once again, this represents a trade-off between rice yields and the risk of flood damage. Similarly, in addition to Thailand's existing modality of flood management in planted rice fields – which is usually a peri-urban flood management measure – manipulation of the growing season is also being tested. Instead of shifting the growing season, short season rice varieties are being evaluated as a flood management measure. Participating farmers grow rice, which is ready for harvest after 2.5 months[6] after which the paddies would

[5] However, the effectiveness of paddy fields in flood reduction is highly dependent on the irrigation method used, with water saving approaches such as alternative wetting and drying or the System of Rice Intensification being most effective.

[6] As compared with the five month rice that is more typical in Thailand.

temporarily convert into a floodwater retention area. This helps the state to manage annual monsoon inundation without having to invest in large-scale infrastructure alternatives. This clearly goes beyond the random use of the paddy field for flood management, but rather represents an intentional use of the available infrastructure to deliver a public good using private land.

This approach is actually nothing new. It uses traditional knowledge from before more intense agricultural practices and demands for land increased. This re-familiarisation with land management approaches not only shows the value of this traditional knowledge, it also helps to use land for multiple purposes, from agriculture, flood retention and fishing. From a nexus perspective, this approach highlights the use of fishery benefits as a synergy and not a trade-off. Nothing is lost as a consequence of this approach, but better management to prepare for a broader range of benefits that can be realised from the same piece of land is required. Furthermore, the gene pool integrity of the capture fishery also improves as a result of increased connectivity of relevant freshwater habitats, which re-distributes nutrients and sediment across the land.

In principle, there is no reason why this approach should not be used on any sort of agricultural land. However, three factors suggest why wetland rice fields are best suited for this: i) the rice fields, being delineated by bunds, are better able to hold flood water (especially if the bunds are built higher than necessary); ii) the drainage of wetland rice area is not expected to keep fields dry; and iii) waterlogging is less of a problem in wetland rice areas than in dryland and other cropland areas.

2.4.2 Lessons learned

Two lessons emerge from this example:

- Nexus can re-purpose existing, single sector infrastructure to achieve trade-offs or synergies between competing sectors. Maximising benefits does not always require investments in large infrastructure, but may be achieved through supplementary infrastructure solutions at a smaller scale. This builds flexibility into existing systems that are often designed for large-scale control and introduces adaptable management into agriculture. Benefits can be derived from improved management and investment in people and organisations, rather than just large-scale infrastructure that comes with high capital, operational and management costs.
- Lost traditional practices and knowledge may re-emerge as highly relevant due to a nexus analysis that allows for a broader perspective on how to solve problems. Sectors, which may create negative development impacts have the ability and mandate to mitigate those problems fully. This in turn may have cultural benefits in terms of societal acceptance of “new” ideas and can empower communities to better manage resources, and localise decision-making. This can help to remove institutional blockages where communities are unsure as to who to turn to and where institutions do not have the expertise or soft skill sets to engage with farmers and communities. For nexus thinking and water management to be fully mobilised and put into practice, farmers need to be empowered.

2.4.3 Relevance to the region

This case study is relevant because: i) rice production is significant in Central Asia (see Table 2); and ii) flood risk is increasing across Central Asia. As such, the use of rice fields for flood

management is relevant to problems a.1/2 and 13 in the typology (see ③ in Table 1). In addition, the potential fishery benefit would help not only food security, but also nutritional security, and diversifies agricultural production and farmers' income streams.

Table 1: Harvested Area of Paddy Rice in the Central Asia Region (Source: FAOSTAT)

	2013	2014	2015	2016	2017
Kazakhstan	89,429	95,277	98,753	94,319	104,500
Kyrgyzstan	7,904	8,062	8,611	9,904	10,704
Tajikistan	11,719	11,108	11,769	13,678	12,527
Turkmenistan	113,716	124,831	134,092	141,204	138,089
Uzbekistan	44,900	48,800	70,500	72,300	71,289
Regional Totals	**267,668**	**288,078**	**323,725**	**331,405**	**337,109**

Community members overlook arid landscape, Uganda ©IUCN/Claire Warmenbol.

2.5 Case Study 4: Senegal River Basin case study

2.5.1 Description

The Senegal River basin is shared by four West African countries: Guinea, Mali, Mauritania and Senegal. The river basin is characterised by high demographic growth, high poverty levels (more than 50% of the population live on less than US $2 per day), and a high dependence on agriculture for income and food security.

In the basin, the quantity of water available is not only a concern because of economic and climate change impacts, including drought across the region. Competing interests related to water distribution and allocation of water among its different uses and different sectors create challenges and demand trade-offs. Indeed, there is a high interdependency between water, food and energy needs. The river basin is a key regional energy provider with several hydropower dams in operation and planned (Figure 3). At the same time, the river is also used for navigation, fishing and trade, making many people reliant on the health of the river system and its surrounding riparian ecosystems.

Figure 3: Existing and planned dams in the Senegal River basin (Source: OMVS)

The *Organisation pour la Mise en Valeur du fleuve Sénégal* (OMVS) is the transboundary management authority responsible to manage the river system. Since its creation in 1972, OMVS has put in place several legal, institutional and political mechanisms to foster regional cooperation in order to develop the shared basin sustainably. Its mandate is to promote food self-sufficiency in the basin, reducing economic vulnerability to climatic fluctuations and external factors, accelerating economic development, and securing and improving the incomes of people living in the basin.

Through unique and innovative regional Conventions (ratified at the regional level in 1978 and 1982), OMVS introduced joint ownership of water infrastructure and basin management for equity of allocation. This included both the allocation of the costs and the benefits based on the needs of the different Member States, and included the capacity of the states to put to use the benefits provided by the river and hydraulic infrastructure. With this, the conventions recognise that developing a river basin provides economic, social and environmental benefits, but those benefits could only be realised and distributed equitably if the costs of that development were also shared. Furthermore, the conventions also acknowledge that those benefits could only be realised if Member States had the capacity to use those benefits, thereby, incentivising countries to develop their capacity to do so. The Water Charter is another key regional legal agreement, setting the participatory framework for equitable benefit sharing, reconciling environmental conservation and social and economic development (with a focus on the nexus basics of energy, agriculture and land use, and water supply).

In addition, OMVS established robust institutional arrangements through the creation of different governance bodies, such as the Conference of the Heads of State, the Council of Ministers, the High Commission (Secretariat), the specific technical operating entities (dams, navigation), the

Permanent Water Commission, a Donor Advisory Committee, the Basin Committee and decentralised consultative committees.

These legal, institutional and political tools, based on the early adoption of principles and practice on benefit and cost sharing, have helped to establish a positive framework for regional peace and cooperation for the management of resources of the basin. Key to this has been maintaining constructive, open and permanent dialogue among countries (even during the conflict between Senegal and Mauritania in 1989-90). Balancing multiple interests across different scales in a transboundary basin and promoting cross-sectoral processes and dialogues to ensure well informed decisions requires large human and institutional capacity.

The macro benefits, such as energy, water supply and food security for the capitals and for national level navigation are evident, but challenges remain. Issues concerning the sustainable management of the basin persist, once infrastructure and other development options 'open up' benefits, making sure those benefits continue requires different ways of controlling expectations from countries and stakeholders. This becomes evident in the context of the management of the existing dams for hydropower generation, the Manantali, Diama, and Félou dams, as well as dams under construction (Gouina), and those proposed (the Gourbassi, Koukoutamba, Balassa, and Boureya dams).

Alongside the development of industry, energy and agriculture, the direct consequences of intensive dam-regulated river flows have had an impact on ecosystem services. Hence, the management of aquatic invasive plants, water quality concerns and equity of access to water resources and the benefits from the river still dominate discussions amongst communities, institutions and countries. Furthermore, water, soils and biodiversity impacts, especially on the fishery sector, remain a priority to achieve sustainable economic and human development. Mobilising large amounts for investment purposes, as in any river basin, continues to be a challenge, though OMVS and the collaboration between countries has significantly helped to secure financial resources for the basin.

2.5.2 Lessons learned

The case study presented above shows that effective and balanced management of the river and the broader basin across different uses and different scales builds on existing benefits from the management of the river. The Water Charter of OMVS played a critical role in raising awareness of decision makers about the shared nature of the water resources. The introduction of this Charter was only possible because existing institutions and structures (such as OMVS itself) promoted shared ownership and were afforded the power and necessary financial resources by its Member countries.

Good data collection, strong engagement with stakeholders and concrete implementation of activities on-the-ground, beyond planning processes, has enabled OMVS to stir the conversation away from questions and issues of water alone, and instead focus on the benefits of the river across multiple sectors and, therefore, achieve benefits along the WEF Nexus.

To progress further, looking to better analyse trade-offs and identify synergies is key in the Senegal basin. Determining a more balanced set of investments combining built and natural infrastructure will help to alleviate pressures on the natural flows and ecosystem services the river provides and this may potentially increase the investment interests in the basin.

2.5.3 Relevance to the region

This case study is relevant to typology problems a.3 and 7 (see ④ in Table 1), but also presents important lessons on transboundary water governance and dialogue leading to agreement. What is most interesting with this example is the focus on benefit sharing from improved management of shared water resources.

There are currently no joint ownership principles present in Central Asia equivalent to those applied in the Senegal River Basin. However, a number of bi- or multi-lateral agreements exist that consider joint water management policy or the coordination of the use of water resources, operation and maintenance of water facilities of interstate use. Central Asia can learn from the experiences of OMVS and the modes of management adopted by riparian countries of the Senegal River Basin to consider a form of cooperation fit-for-purpose in the particular context of the region.

African woman farmer ©Shutterstock/Rafal Cichawa.

2.6 Case Study 5: Agribusiness as natural infrastructure in the Southern African region

2.6.1 Description

The sustainability of the entire water economy of the Southern African region relies on Lesotho's highlands, a critical source of the water tower, which supplies almost one million square kilometres. The soil needed to regulate flows into the Orange/Senqu river is being eroded at an alarming rate. Reasons are mainly over-grazing and pasture lands that are located in inappropriate land areas. One estimate suggests that Lesotho's soil flows into South Africa at a rate of 1.3 tonnes per second. A UN forecast suggests that at current rates of erosion, all the soil will have gone by 2040, leaving only bedrock. The consequences would be dire to the regulation of water flows and the deposition of the soil are a major risk to downstream dams.

In response, a private company has embarked on a commercially funded approach that opens up non-traditional pathways to ensure water, food and possibly energy security in unconnected rural areas. The company sells bamboo seedlings to the government, which distributes them to communities in the degraded areas. The root systems of bamboo are shallow, massive, fibrous networks that are very effective in holding soil in place. Planted along streams or irrigation gullies it can help to stabilise the soil, which in turn reduces water loss in high value horticulture or fodder production and channels water for livestock to areas that are better suited pasture lands. In turn, the company buys back the mature bamboo stalks from the producer groups and uses them in different value chains as a valuable resource in a heap of industrial applications. The arrangement between the company and the government provides a commercial return for the company and supports the government's effort in its restoration strategy for a severely degraded landscape that has major impacts on regional water and energy security.

2.6.2 Lessons learned

The private sector can play a central role to realise sustainable development along the Water-Energy-Food Nexus. The case study presented above illustrates how:

- WEF Nexus considerations provide a business opportunity for companies and a development opportunity for local communities;
- Thinking from a nexus point of view could give an impetus to investments, because investing in a project that involves all these three sectors at the same time has a higher return than one that considers them individually: the interconnection between the three sectors makes them act on each other with a multiplier effect;
- Medium scale agribusiness initiatives, where the opportunity and market are available, can enhance water and soil resources and therefore contribute to a wide range of solutions for water and agricultural development; and
- Comprehensive synergies between resources can provide financial returns for both the private sector and public goods that can be utilised by farmers and communities.

2.6.3 Relevance to the region

Particularly for issue items a.12 and 14, and b.2 (see ⑤ in Table 1), small and medium-sized enterprises (SMEs) could play a vital role in supporting economic growth and combating poverty in the Central Asian region. Similar to the case study presented above, enterprises could play a key role supporting governments in their efforts to adopt integrated, economically and ecologically sustainable interventions to ensure water, energy and food security in light of climate change. This would be a viable option, especially since governments often lack the capacities and resources to solve nexus problems. To date, the development of such public-private ventures in the region is hampered by various factors, such as fragmented knowledge of business administration with regard to human resources, marketing, financial management and weak legislative and regulatory frameworks, as well as a low level of regional economic cooperation.

Rhine river in Rheinland-Pfalz, Germany ©Shutterstock/Dmitry Eagle Orlov.

2.7 Case Study 6: Multi-stakeholder cooperation in the Rhine Basin

2.7.1 Description

Europe's Rhine River is the continent's most intensively used river. It drains water from nine countries, and flows through four. Some 60 million people live in the basin of whom 50% depend on it for drinking water. In addition, it includes 6 major industrial hubs, while almost 50% of its adjoined land area is used for agriculture and 30 million tonnes of goods are shipped up and down annually. Such intense and diverse use has inevitably resulted in conflict: between water supply, agriculture and the energy sector, which uses the water in its cooling towers; on issues of agricultural, industrial and urban pollution; and heat pollution from the energy sector.

Several nexus-informed approaches and tools are being applied, all of which are institutional in nature and aim to achieve a win across all relevant sectors:

- International cooperation draws upon the legal basis provided by the Convention on the Protection of the Rhine as well as various European directives and regulations requiring coordinated implementation in the entire watershed, such as the European Water Framework Directive, the European Flood Management Directive, the Eel Regulation and others.
- Through the International Commission for the Protection of the Rhine (ICPR), nine states and regions in the Rhine watershed closely co-operate to harmonise the many interests of use and protection in the Rhine area. Focal points of work are sustainable development of the Rhine, its alluvial areas and the good state of all waters in the watershed. Decisions

are taken in the annual plenary assembly on matters of political importance and the basis for coherent, co-ordinated programmes of measures established.

- Establishment of mutually understood, multi-sector objectives with well-established and agreed upon targets and standardised metrics on ecosystem improvement, flood prevention and flood protection, protection of water quality and groundwater protection.
- Contractual arrangements for and between various uses.
- Negotiated solutions between various basin and sectoral stakeholders and institutionalised cooperation through the formation of Conventions of shared resources, water charters or other legal frameworks.
- Economic instruments and cost sharing among Member States.

2.7.2 Lessons learned

In the last decade of the last century the ICPR-activities were a model for many other river basins. This is largely attributed to the working and expert groups that have clearly defined mandates on all relevant technical issues arising from the implementation of the Convention on the Protection of the Rhine and from European law.

This example shows that nexus solutions are not limited to capital investment. Institutional capacity building and dialogue, alongside well-enforced regulatory frameworks also have an important role to play. In addition, this case demonstrates the potential benefits that can accrue to the establishment of mutually agreeable transboundary government structures. However, the literature suggests that, like IWRM, management of the river is still dominated by representatives of the water sector (McNamara and Sycz, 2018).

2.7.3 Relevance to the region

This case study is also relevant to the crosscutting typology problem a.6 but is also relevant to a.9 and a.11 (see ⑥ in Table 1).

Though there are some transnational organisations and structures in the region who are functioning within their mandate to coordinate water use, distribution and allocation, their legal framework is mostly limited to the water sector, with minor overlaps with other sectors. The Interstate Commission for Water Coordination of Central Asia acts as a high-level political platform that decides on water distribution annually. However, since its mandate is limited, it cannot cover all aspects of rational water use, hence, some level of reformation is required to add additional elements to its mandate and to ensure that transboundary cooperation is not only water-centric.

Water hyacinth at Lake Naivasha, Kenya ©Shutterstock/Deborah Benbrook.

2.8 Case Study 7: Multiple benefits of water Hyacinth control in Southern Africa[7]

2.8.1 Description

Water hyacinth is one of the fastest growing plants, blocking sunlight from entering the water and preventing native vegetation from growing. This reduces the oxygen levels in the water, affecting fish and other aquatic life. Its rapid growth can dramatically reduce water movement, block infrastructure and channels and absorb nutrients essential for aquatic ecosystems. As it dies and decays it further depletes the amount of dissolved oxygen in the water and can become a breeding ground for mosquitos. To address the issue of water hyacinth invasion in South Africa, several iterations towards nexus-driven solutions were developed. The first iteration acknowledges the potential energy and food security benefits of the invasive plant. It suggests the drying of the biomass for direct burning as a source of energy and composting the rest for use as a manure to support agricultural food production. However, this was found to under-use the full potential of water hyacinth. A second iteration suggests to feed the biomass into a digester. The resulting methane could be used as a source of energy and the waste product could be used as fodder for livestock. The third and final iteration suggests to feed all the biomass to livestock, contributing most significantly and directly to food security. Livestock excrement was then fed into the bioenergy digester, which generated more methane than in the second iteration. By the time that

[7] This case study was presented on 24 May 2017 during the third, nexus themed day of the 7th SADC River Basin Workshop (Msibi 2017).

the digestion was complete, the digested material had been converted into high quality, organic fertiliser, which was used to increase crop yields, contributing once again to food security.

2.8.2 Lessons learned

A solution to a problem in the management of water resources can open up pathways towards energy and food security. As with Case Study 4, this case study confirms that nexus can be applied at a small scale to provide localised multi-sector sector solution pathways at the local community level that entail commercial opportunities that transform problems into solutions for other sectors.

2.8.3 Relevance to the region

Because water hyacinth is not (yet) a problem in Central Asia, this case study has no immediate relevance to a problem in the region. However, it has very significant crosscutting relevance. It is an example of how a nexus approach can use a river basin solution to provide solutions to other challenges in the basin, which can be solved by taking into account other sectors. At the same time, some invasive vegetation, such as reeds and typha grasses that pervade the large public irrigation systems in Central Asia cause similar challenges in water flow.

Irrigation sprinklers in the Salinas Valley of central California, USA ©Shutterstock/David Litman.

2.9 Case Study 8: Solving inefficient irrigation in Indonesia

2.9.1 Description[8]

The Jati-Lahur reservoir and hydropower station is situated some 75 km to the South West of Jakarta, the capital of Indonesia. Its waters flow through Jakarta and into the Java Sea. On its way, it flows through an area of smallholder-irrigated rice paddies (Figure 4). Water for the rice irrigation scheme in this area comes from the Jati-Lahur reservoir and is regulated by an abstraction permit scheme since 2003. In addition, the river is also used by an artisanal capture fishery sector.

Targeted capacity building activities over the years empowered rice farmers to grow more rice with less water. They could have continued abstracting their permitted amount of water from the Jati-Lahur reservoir, while also expanding the total irrigated area (Figure 5). This would have had no impact on the access of water for downstream populations and urban centres. However, the farmers opted for a second approach, where they increased rice yields on the existing area and reduced their total water use. As shown in Figure 6, downstream flows increased, contributing to improved capture fishery benefits. Additionally, water saved by the farmers became available to industry surrounding Jakarta. Additionally, the farmers received compensation for the difference in water use compared to their permitted amount. As a result, the economic productivity of water use in the basin, physical yields and overall food production increased, while competition for water decreased.

[8] Adapted from Riddell, 2018

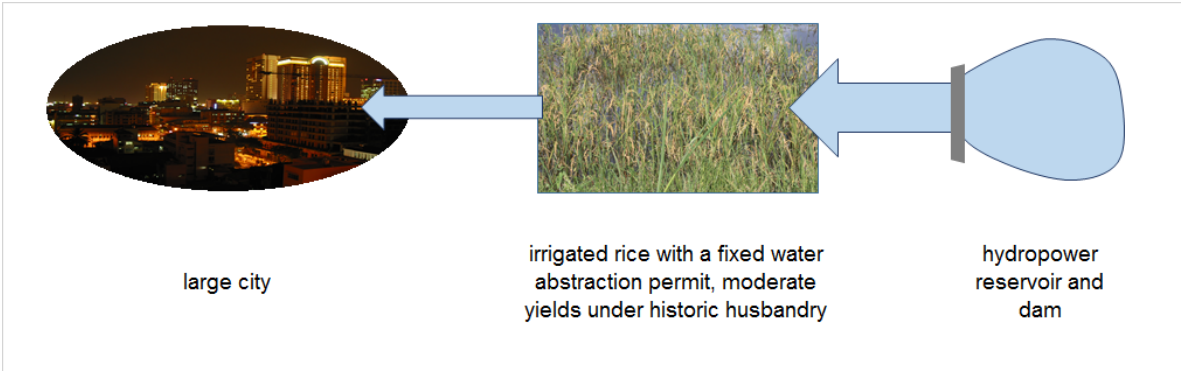

Figure 4: A Schematic Showing Baseline Conditions in the Jati-Lahur Basin

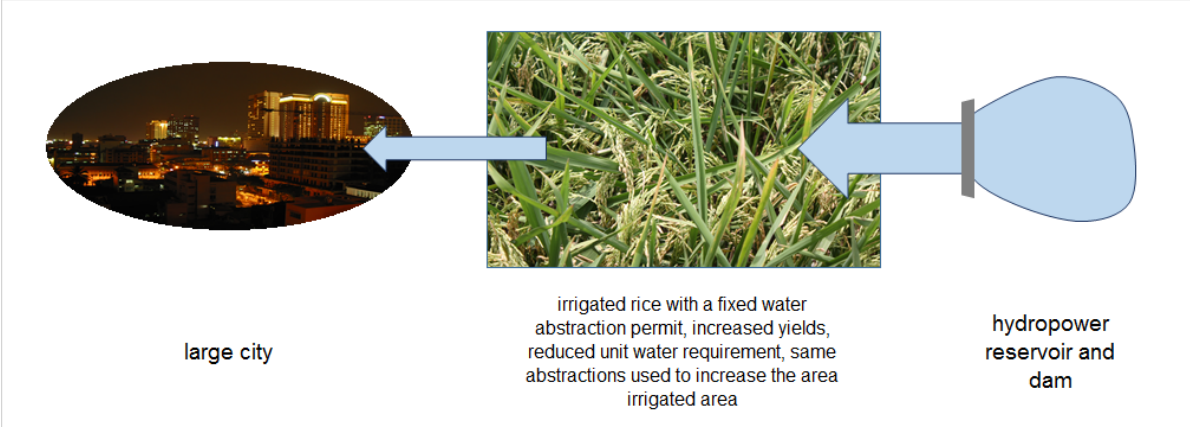

Figure 5: A Schematic Showing an Expanded Irrigated Area in the Jati-Lahur Basin

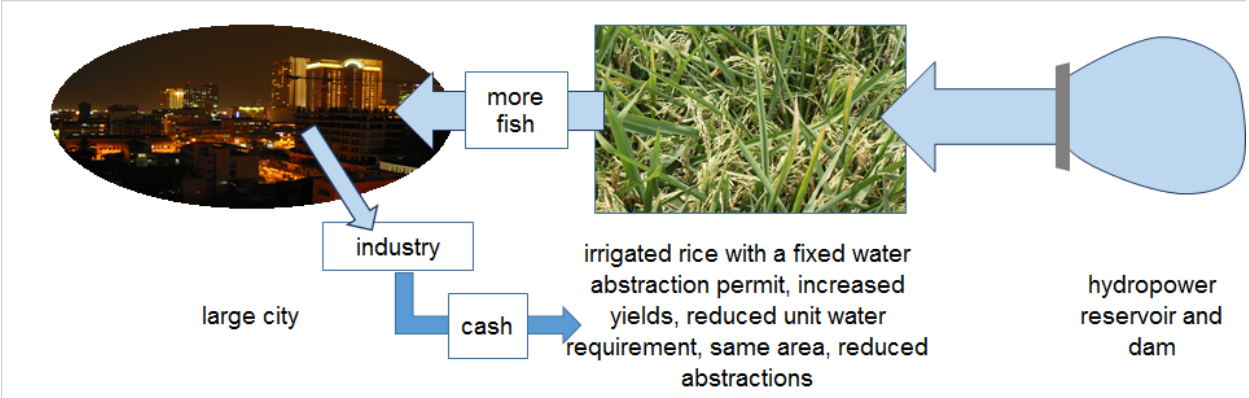

Figure 6: A Schematic Showing the Results of improved water use in the Jati-Lahur Basin

2.9.2 Lessons learned

The lesson that can be derived from this case study is that significant multi-sector synergies can be achieved through a bottom-up farmer led approach. The support of government and its regulatory agencies to issue a permit for allocation of water resources was key to make farmers consider water management options. In this case, targeted training helped to improve farmers' understanding of irrigation and yield production, and the broader basin opportunities from 'trading'

a portion of their water permit to industry, maximising the value of water to the basin and the broader economy.

This approach demonstrates that for the nexus to be fully realised, a combination of human capacity development, governance improvements and collaboration among sectors was needed to realise the full value of water opportunities.

2.9.3 Relevance to the region

In the above presented case study, the physical water management system did not change. Instead, what changed was the awareness and skills of farmers and the governance of the water allocation system. This example is relevant to typology problem a.5 (see ⑧ in Table 1).

Inefficiency in water use for irrigation is a key issue in the Central Asian region. Irrigation efficiency can be defined in several ways. Engineers with a vested interest in programme budgets tend to favour increases in physical water efficiency. But in light of an absence of measures and incentives to re-allocate excess water of the assumed farming system, there is a risk that farmers will use the excess water to irrigate farming systems that are even so slightly profitable rather than allowing for more water to flow back into the hydrological system. However, the assumed return of water to its sources, such as stream, river or built canal, in reality often means a decrease of water security downstream. Most importantly, whilst efficiency is marketed to save water, re-use water and increase agricultural yields, often what it results in is a decrease in the productivity of water at the broader basin level.

3. Nexus and non-nexus scenarios for Central Asia

3.1 Scenario development methodology

The future is unknown. Even so, policy makers, planners, decision makers and national development partners sometimes require a broader 'horizon view' to inform their decision-making. Looking beyond single sectors brings greater understanding of the trade-offs and, therefore, where opportunities for synergies can be best utilised.

Although scenarios become little more than storylines of a possible future, scenarios are a powerful way to raise awareness of likely outcomes of different courses of action or indeed of non-action. Scenario analysis provides a useful point of departure for follow-up discussions and deliberations across sectoral silos. The scenarios are aligned along two key axes: (i) the extent to which institutions are strengthened and mandated to adopt a more transboundary approach and (ii) the extent to which planning remains trapped in silos or has been redirected onto a more multi-purpose, multi-sector basis. A scenario approach based on these two axes is presented below as Figure 7.

In the context of Central Asia, the hydropower potential of the Aral Sea Basin plays a key role. Infrastructure developments in the region that have transboundary impacts on several sectors are generally realised unilaterally. This can lead to unwanted tensions and affect the livelihoods of populations of neighbouring countries. By reflecting on the case studies presented above and the four scenarios addressing nexus issues to a greater or lesser extent, it is hoped that key actors in the region are motivated to examine innovative solutions and to adopt nexus thinking.

3.2 Scenarios for Central Asia[9]

3.2.1 Scenario 1: costly inaction

Weak national institutions in the water, energy and food sectors continue to operate and invest in silos. Budgets for investments in infrastructure are increasingly stretched, while the revenues required to ensure good economic returns on those investments are derived from single sectors, which likely have to compete with other sectors for natural resources and possibly for operational finances. As a consequence, economic growth slows down or even declines while water, food and energy security deteriorate for a growing population base, with prices for food and energy increasing in indirect proportionality to supply.

In the absence of affordable recurring cost recovery caused by tightening public and societal finances, built infrastructure becomes dilapidated and unserviceable. This leads in turn to increased direct pressure on natural infrastructure, such as watersheds and wetlands. Consequently, floods and landslides become more frequent and severe; pollution increases while public health decreases putting more demand on public finances and crucial environmental services continue to decline.

3.2.2 Scenario 2: wasted skills

In this scenario, institutional capacities have been strengthened and transboundary cooperation increases, not least with respect to the sharing of the costs and benefits accruing to basin level

[9] These descriptions have been partially derived from Pohl 2017.

infrastructure. But silo thinking still prevails, such that trade-offs, compromise and synergies remain elusive. For example, the operating rules of hydropower dams remain prioritised towards power generation and dams are kept as full as possible. Although energy security might increase, institutional hegemony means that water remains immobile in the economic sense[10] and becomes ever scarcer in relation to the growing demands upon it. Agricultural productivity remains at a low level or even declines while pollution increases, while habitat and biodiversity continue to decline along with ecosystem services.

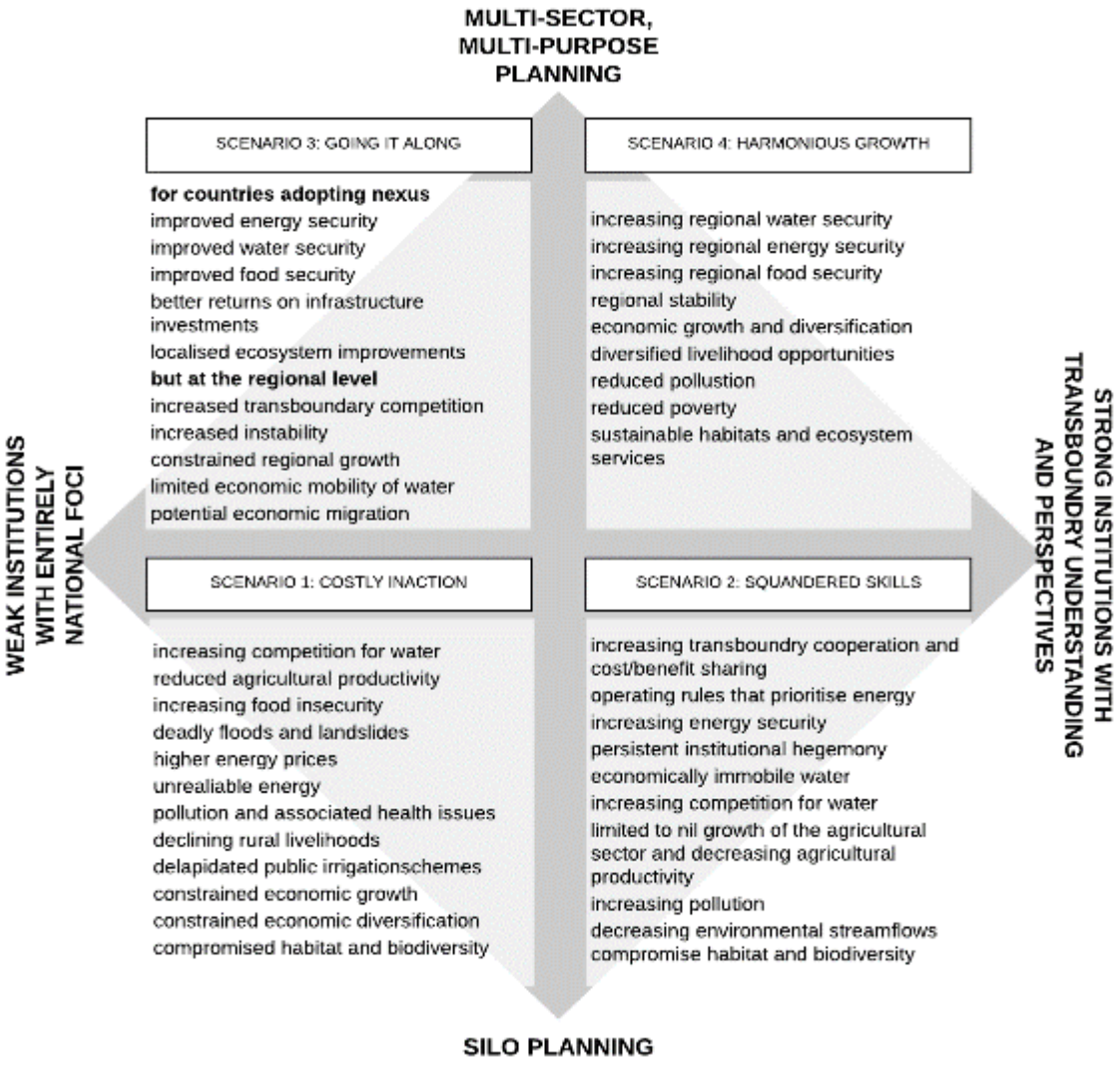

Figure 7: Four possible future scenarios in Central Asia

3.2.3 Scenario 3: going it alone

Nexus thinking at the national level has increased water, energy and food security at the national level, economic returns on public infrastructure will be steadily improving and the recurring costs of operation and maintenance will be easier to finance, either by state transfers or by increasing affordable service charges. With a lack of consideration and establishment of transboundary

[10] Water is said to be economically mobile when surplus water can be allocated or reallocated in a way that reduces its opportunity cost.

institutions at the regional level, competition for water resources will increase, constraining regional growth. This in turn could lead to instability, limited economic mobility of water and possibly destabilising economic migration.

3.2.4 Scenario 4: harmonised growth

In this optimal scenario, well trained and well-equipped institutions are cooperating across both sector and national boundaries. As a result, water, energy and food security is increasing throughout the region, which itself becomes more stable. Economic growth and diversification will be facilitated, leading in turn to increasing and diversifying livelihoods, reducing poverty, reducing pollution and burgeoning regional trade. Utilisation of natural resources will become more productive and more sustainable in terms of social equity, economic growth, sustainable habitats and valuable ecosystem services.

3.3 Ways forward in the context of Central Asia

The scenarios described above make a strong case for nexus thinking at national level as well as at the regional level. Increasing resource insecurities, especially related to transboundary waters of the Aral Sea Basin, not only pose threats to national security concerns, and with that the well-being of the population, but also to the socio-economic development of the region as a whole. Though water may not be the main cause of tensions among Central Asian states, it is often considered one of the underlying stress points due to its importance for basic human needs and economic survival.

The feedback from stakeholders in Central Asia and the results of an analysis of the regional institutional situation[11] both stipulate nexus interventions from two levels:

(i) At the **national level,** nexus perspectives need to be strengthened and incorporated into national policies, strategies and plans; capacities and bottom-up approaches need to be built and local solutions to regional nexus problems sought. Opportunities to help inspire action on national nexus issues (Scenario 3) are:
   a. Consider localised, small-scale solutions that may have impacts for the entire river basin and, therefore, the region as a whole (learn from case studies 3 and 7)
   b. Re-think existing infrastructure and how improved management, governance and capacity building may provide additional benefits, also considering traditional practices (learn from case studies 3 and 4)
   c. Involve the private sector to diversify sources of investment with a view to producing financial returns for businesses and public goods (learn from case study 5)

(ii) At the **regional level**, it will be necessary to develop regional development objectives through dialogue and negotiation, share benefits across the entire Aral Sea Basin, and strengthen regulatory frameworks for joint decision-making. Opportunities to help inspire action on regional nexus issues (Scenario 4) are:
   a. Dialogue platforms to coordinate planning and agree on data to inform higher level development objectives (learn from case studies 1, 4 and 6)

[11] See Meyer, K. (2019). *Regional institutional arrangements advancing water, energy and food security in Central Asia*. Belgrade, Serbia: IUCN.

b. Strengthen regional organisations, including a strong and enabling regulatory framework, to enable benefit sharing in a transboundary context (learn from case studies 4 and 6)
c. Increase stakeholder engagement and implement concrete activities (learn from case study 4)

The scenario analysis further indicates where vertical linkages between the national and regional levels are possible to support the Central Asian region in its efforts to apply nexus approaches to address issues of water, energy and food security (linking Scenarios 3 and 4):

a. Engage stakeholders early in an iterative planning, negotiation and decision-making approach to generate common understanding (learn from case study 2)
b. Utilise complex modelling and other tools to quantify Water-Energy-Food interactions to stimulate dialogue on different scenarios, trade-offs and benefits (learn from case study 2)
c. Build capacities of existing organisations and individuals to move beyond the water domain and increase nexus understanding (learn from case studies 2, 6 and 8)

Farmer driving tractor during harvest ©Shutterstock/Tong Stocker.

4. Conclusions

The case studies presented above present an opportunity for Central Asia to learn from global experiences on nexus and may inspire action and help identify opportunities in the region to solve some of the issues faced by Central Asia as identified in Table 1. The case studies do not, however, produce a comprehensive catalogue of methods, tools and approaches. In fact, there is an expanding body of research on nexus methodologies and approaches, but these mainly stay within academic circles.[12] Similarly, the UNECE publication on methodology development for the nexus in transboundary basins[13] offers some practical advice for countries to follow as step-wise engagement across sectors. UNECE has already completed an assessment of the water-food-energy-ecosystems nexus in the Syr Darya basin.[14] Previous work in Central Asia identified possible nexus projects including: Payment for Ecosystem Services; Building an Integrated Basin-Wide Information System; Strengthening Regional Economic Integration; A Network of Training Centres for Improved Irrigation Capacity Building and Service Provision; and a Network of Nexus Knowledge & Innovation Centres. Further information on these can be found in the report: Triggering Cooperation across the Food-Energy-Water Nexus project in Central Asia.[15]

However, every nexus intervention needs to be designed and planned within the specific context. Even though, case studies provide important insights, they need to be supplemented by concrete

[12] There are a myriad of different studies and approached to determine or 'assess' the nexus, all using different approaches. For recent reviews of this work see Brouwer et al (2018), Kurian (2017), or Albrecht et al. (2018).

[13] http://www.unece.org/fileadmin/DAM/env/water/publications/WAT_55_NexusSynthesis/ECE-MP-WAT-55_NexusSynthesis_Final-for-Web.pdf

[14] http://www.unece.org/fileadmin/DAM/env/water/publications/GUIDELINES/2017/nexus_in_the_Syr_Darya_River_Basin/Syr-Daria-FINAL-WEB-.pdf

[15] http://waternexussolutions.org/2p9/triggering-cooperation-across-the-food-water-energy-nexus-in-central-asia.html

awareness raising and targeted capacity building activities. This is to help ensure that stakeholders are empowered to take practical steps towards applying nexus thinking in concept design and to identify and agree what could be possible for investment planning and implementation in existing approaches, not just new ones on the horizon. Where key actors have the knowledge and skills to design, develop and negotiate joint investment projects that promote water, energy and food security, all three sectors can benefit, including by increasing returns on investments. The nexus also highlights the need for greater integration on core elements such as data collection, sharing and interpretation of knowledge. Through dialogue, opportunities can be created to bring together people with a variety of experiences from across sectors to brainstorm, and exchange knowledge, with the ultimate aim to move to developing and implementing practical actions.

In Central Asia the need for investment can act as a key driver for this and should help to drive new and innovative conceptual designs (Gyawali, 2015). Yet, to ensure continued dialogue and to avoid complexities across borders, Central Asian states will need to focus on reconciling national priorities (Scenario 3) with regional development needs and areas requiring urgent action (Scenario 4) – e.g. increasing water scarcity. The case studies demonstrate that options from outside conventional sectoral discussions and rigid planning processes need to be considered. A range of approaches are available to design dialogues that can help to identify nexus opportunities, using innovative workshops and discourse mechanisms. And although many assessment 'methodologies' are available, recent research by Albrecht et al. (2018) suggest that stakeholders benefit from framing their own assessment approach to ensure they get the value back they need contextualised to their situation and priorities. These can focus on resource efficiency, new technological possibilities and investments, and from here can determine the governance reforms needed or the pilot opportunities to trial new approaches.

Central Asian countries could explore how to design effective investments across sectors, so that they can benefit from efficiency improvements derived from the application of the nexus approach. The case studies above demonstrate the great potential for solutions that can generate increasing returns on investments in monetary terms and the possibility of reducing costs through the nexus approach, although sometimes, increased investment is needed to gain greater returns. Efficiency gains are also possible for existing as well as new infrastructure, provided effective multi-sectoral negotiation of trade-offs takes place. Efficiency gains exist also in policy reform and through greater inter-sectoral discussion that breaks down the hierarchical barriers that can exist between sectors. This can help to unlock approaches that can achieve multiple goals through a single investment, boosting economic gains as well as increasing social and environmental benefits.

There are many ways to not agree about the nexus. What becomes clear is that it would be a competitive advantage for all institutions, public, private, etc., to better understand the cause and effect relationships they are involved in through both implementation of their mandates, and policy actions and reform. Through better identification of risks, sharing the risks, and optimising the trade-offs that need to be made between sectors, advantages for all sectors can emerge.

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