THE NEXUS APPROACH IN ENVIRONMENTAL RESOURCES MANAGEMENT

PROCEEDINGS

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The Nexus Approach in Environmental Resources Management

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Background

Relating to environmental resource management, the term *nexus* was introduced for the first time during the 1980s. Ever since, resource management circles throughout the world have continued to use the nexus concept to explain the interdependencies between different resources. Some examples of these nexuses include water-electricity, water-energy, groundwater-electricity, water-agriculture and, finally, water-energy-food (WEF). In particular, this last example, the WEF nexus, made nexus thinking more popular among international academia and in policy circles in the lead-up to the Bonn 2011 conference on the "The Water, Energy and Food Security Nexus – Solutions for the Green Economy". At the Bonn 2011 conference it was argued that such an approach would result in improved water, energy, and food security by integrating "management and governance across sectors and scales". It also pointed out that this approach would reduce trade-offs, build synergies, promote sustainability, and ease the transition to a green economy.

Dialogues in and after 2011 positively influenced many research and capacity development organisations to take a serious look at the Nexus Approach. Interestingly, the United Nations University (UNU) established its latest campus, UNU-FLORES in Dresden, to promote integrated management of water, soil, and waste based on nexus thinking. Many other research groups and capacity developers also reoriented or fine-tuned their agendas to include aspects of the Nexus Approach in environmental resource management. As of now, there are at least a dozen leading institutions in Europe and North America working on this topic: the Stockholm Environment Institute (SEI), Global Water Partnership (GWP), the German Federal Ministry for Economic Cooperation and Development (BMZ), The Water Institute at the University of North Carolina (UNC), and the Nexus Research Group at Texas A&M University (TAMU) to name a few. Although the main direction is common, the work conducted in each of these institutions is unique. While the uniqueness enriches ongoing discussions, the inability to send a unified message can sometimes confuse or mislead. UNU-FLORES believes that a single, unified message would lead to better understanding of the Nexus Approach.

In this context, UNU-FLORES gladly accepted the invitation from the University of Tabriz (UT) in Iran to co-organise a workshop on the Nexus Approach in Environmental Resource Management. We believe that bringing different viewpoints to one platform is crucial and so, in addition to UNU-FLORES participants, we involved as many external contributors as possible. The team of contributors included experts associated with the Stockholm Environment Institute (SEI), Global Water Partnership (GWP), Deltares, UNESCO-IHE, Urmia University (UU), Tarbiat Modares University (TMU), Sharif University of Technology, and the United Nations University (UNU). UT recently established a multi-disciplinary research entity, the Institute of Environment (UTIE), to tackle regional environmental issues, including the well-documented case of Lake Urmia. Thanks to the efforts of UTIE, contributors and attendees at the workshop learned about the environmental issues related to Lake Urmia not only through the discussions, but also through a field visit to the lake. During this collaborative activity the international team of visitors had an opportunity to study the environmental issues unique to the region and local experts learned how to apply nexus thinking to solving these issues.

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Acronyms

ADB	Asian Development Bank
BCM	billion cubic metres
BMZ	Federal Ministry for Economic Cooperation and Development, Germany
DoE	Department of Environment
GWP	Global Water Partnership
HELCOM	Baltic Marine Environment Protection Commission
ICPDR	International Commission for the Protection of the Danube River
ICPR	International Commission for the Protection of the Rhine
IFAD	International Fund for Agricultural Development
IWRM	integrated water resources management
JICA	Japan International Cooperation Agency
KTH	KTH Royal Institute of Technology, Stockholm
MCM	million cubic metres
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
SEI	Stockholm Environment Institute
SUWA	Safe Use of Wastewater in Agriculture
SWAT	Soil and Water Assessment Tool
TAMU	Texas A&M University
TMU	Tarbiat Modares University
ULRP	Urmia Lake Restoration Program
UN	United Nations
UNC	University of North Carolina
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNU	United Nations University
UT	University of Tabriz
UTIE	University of Tabriz Institute of Environment
UU	Urmia University
WEF	water-energy-food

Section 1: Introduction

The Nexus Approach to sustainable resource management can help minimise environmental degradation associated with poor resource planning, while at the same time supporting policy implementation for protecting the environment. While this concept has received considerable attention in academic discussions in natural resource management in Europe and North America, there are few examples of discussion and implementation in regions such as the Middle East. This workshop in Tabriz, Iran, was tailor-made to bridge this gap. Iran is a country that regularly grapples with the challenges of drying lakes and rivers, declining groundwater resources, water contamination, and numerous other water-related issues. Lake Urmia, which is located not far from Tabriz where the workshop was conducted, is a prime example. Lake Urmia has been shrinking due to mismanagement of water and so provided an excellent, fitting backdrop to many of the discussions during the workshop.

The workshop spanned two days. Day 1 was dedicated to understanding regional issues. Three local experts shared information on ongoing environmental issues in the region and the solutions attempted so far. This was followed by a field visit to the Ajichai River, Tabriz Thermal Power Plant, and the Lake Urmia area and causeway, where the workshop attendees witnessed the challenges for themselves. Day 2 of the workshop was dedicated to discussing how nexus thinking may help find solutions. Five international experts explained their views and ideas. At the end of the day the workshop concluded with a wider discussion joined by all contributors and attendees.

Section 2: Lake Urmia and Other Regional Environmental Issues

Prof. Moghaddam Vahed, Vice-Chancellor of UT welcomed all participants to Day 1 of the workshop, which was dedicated to understanding the environmental issues faced by the region. Three local experts gave their insights. First, **Prof. Naser Agh** (University of Urmia) presented an overview of the history of Lake Urmia up to the present day. He discussed the internal and external causes that have affected the lake: a reduction in precipitation, rapid unbalanced development in the agricultural sector, construction of several dams, changes in the lake geomorphology, and other causes.

Next, **Prof. Saeed Morid** (Tarbiat Modares University) discussed the interactions between water, food, and the environment in the Lake Urmia basin and noted that the current condition of the lake needs new policies. Prof. Morid has investigated the impacts of the Lake Urmia Restoration Program (ULRP). Even by reducing water use by 40% on 100,000 hectares the 3,100 million cubic metres (MCM) representing the lake's water requirement cannot be met. He argued that new strategies, such as demand management, revising the development plan, revising self-sufficiency policies, engaging people and improving social assets, are needed to ensure the lake's survival.

Finally, **Prof. Ali A. Alamolhoda** (Sharif University of Technology) reviewed achievements in developing water resources and combating environmental degradation in Iran. The remainder of the day was allocated to the field visit, during which the attendees had an excellent opportunity to see how the allocation of water interconnects with the energy and agricultural sectors. Appendix 1 captures some of the moments during the field visit.

Lake Urmia, situated between the provinces of East Azerbaijan and West Azerbaijan, used to be one of the world's largest saltwater lakes. In recent years it has shrunk to 10% of its former size. Many believe that unwise management of water resources, including damming the rivers that flow into the lake and pumping groundwater from the surrounding area, are among the main reasons why the lake has shrunk. What better backdrop to discuss how nexus thinking can help solve critical issues of environmental resource management, such as the degradation of Lake Urmia?

Section 3: Inaugural Session

Well over two hundred participants – mainly professors, researchers, PhD students, government officials, and UT students, mostly representing water and environmental disciplines – attended the inaugural session on Day 2.

Prof. Mohammad Reza Pour Mohammadi, the Chancellor of UT, welcomed the audience. In his speech, he emphasised that environmental management is one of the focal research areas at UT and that UT is ready for international cooperation on this critical issue. He also explained the need to establish an international perspective at UTIE. **Prof. Kaveh Madani**, Vice-Chair of the Iran Department of Environment (DoE) also gave a brief welcome speech.

Prof. Reza Ardakanian (Minister of Energy, Iran and the Founding Director of UNU-FLORES), who had been scheduled to attend the welcome session, sent his greetings in a written message read by **Dr Mohammad Fazeli** (Advisor to the Minister of Energy, Iran). The message read by Dr Fazeli pointed out that all environmental problems have histories relating to specific policy issues.

Institutional economics has taught us that history matters; we should recognise that previous policies and actions have created unsustainable patterns of water, soil, and energy use, and have created path dependencies which limit our options for restoration. A more inclusive approach, applying social analysis with a wide spectrum of contributions from economics, sociology, anthropology, and policy, in addition to engineering and science, is now needed. Applying such an inclusive approach needs a special focus on the methodologies of interdisciplinary investigation, participatory planning and action, and evaluation and coordination. A combination of theory and methodology is needed to organise this more integrated approach.

The keynote speaker **Prof. Hiroshan Hettiarachchi** (UNU-FLORES) began his talk with a brief introduction to the United Nations (UN) and the United Nations University (UNU). He also explained that the mandate of UNU-FLORES is to promote the Nexus Approach to managing water, soil, and waste, and described UNU-FLORES activities in these areas. Prof. Hettiarachchi said that when we are talking about the water-energy-food (WEF) nexus, the first questions to ask are: What is the Nexus Approach? What does it mean? He argued that there is no universal definition. The Nexus Approach is also not limited to environmental or any other resource issues. Prof. Hettiarachchi said that he believes that the Nexus Approach means broad integration of more than one discipline that can help us optimise resource use.

Prof. Hettiarachchi went on to briefly describe the history of nexus thinking, from its appearance in the early 1980s linking food and energy to its evolution as a game changer in the dialogue at the 2011 Bonn Conference. He said that he believes that food security has not yet been achieved and explained how we can address food security. Since, even today, one in nine people do not have access to sufficient food there is justification for thinking about multiple ways to address global food security. Increasing the efficient use of resources through the integrated approaches considered in nexus thinking could be one practical solution.

Prof. Hettiarachchi also talked about how waste is related to the other resources often discussed in the Nexus Approach. "Waste is rarely seen as a resource by the general public. For many, waste has no value." For Prof. Hettiarachchi, this is a concern. He described how we usually ignore the value in waste by giving examples: nutrients in food waste, gold in mobile phones, and the phosphorous that is usually lost in wastewater. Finally, he illustrated the practical application of nexus thinking using three projects: NEWater, the ultra-pure water produced from wastewater in Singapore; SUWA (Safe Use of Wastewater in Agriculture) in Jordan; and biogas predominantly produced from agricultural feedstock in Germany.

Prof. Hettiarachchi stressed that the Nexus Approach is still evolving as a concept. He also insisted that waste is a resource and can play a strong, helpful role in nexus thinking. However, he pointed out that there is a great deal of work to do to influence public perceptions and find sustainable mechanisms.

Section 4: History and Development of Nexus Thinking

The history and definition of integrated water resources management (IWRM) was the point of departure in the next talk given by **Dr Fritz Holzwarth** (Former Rector, UNESCO-IHE). Referring to the Global Water Partnership, he defined "IWRM as a process which promotes the co-ordinated development and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems". He indicated that water uses for people, food, energy, and industry are sub-sectors encompassed in IWRM. Accordingly, he inferred that Lake Urmia must be seen as a whole system.

In his presentation, Dr Holzwarth recognised that water resources have ecological, social, and economic dimensions. Water supplies, and food and energy security are three dimensions of sustainable development. The nexus perspective is thus important because it helps us to understand the interdependencies across water, energy, food, and climate policies. The second reason for the significance of the nexus perspective is that it opens the eyes to mutually beneficial responses and the potential of cooperation. The third reason, is that the nexus perspective helps to identify policy levers for implementing a common agenda for the future that accelerates access, creates more with less, and invests to sustain ecosystem services. He argued that "achieving long-term water, energy and food security for all is possible. But business as usual is not an option".

Dr Holzwarth explained that the nexus perspective is central to the themes of Rio 2012, the Green Economy, Bonn 2011, and Rio+20. Finally, he concluded by saying that lake basin planning and its implementation needs all stakeholders to be involved, and that all interests, including water utilities, industry, agriculture, hydropower, thermal power, and ecosystems/wetlands, need to be taken into account. At the end of his presentation, he emphasised that lake basin management needs a sound governance structure.

Section 5: Adaptation of the Concept to Local Settings

Dr Louise Karlberg (SEI) argued that the word nexus is currently seen as a buzzword. In her talk she explained how the nexus concept has been applied by giving examples from Ethiopia, Zambia, and Rwanda. In Ethiopia, a project involved local stakeholders to seek answers to the following three questions:

- Policies and institutions – WHO?
- Stakeholder engagement – WHAT?
- Quantitative analysis – HOW?

Dr Karlberg then discussed policies and institutions, taking examples from agriculture and energy. In the rest of her talk she incorporated group discussions as an interesting tool to involve workshop participants. During the first group discussion, she asked the audience to name the main actors and institutions which would need to be involved in a nexus project in Lake Urmia and to identify the main policies that are relevant to analyse the case. After discussing the importance of stakeholder engagement, she analysed the results of stakeholder engagement, including identifying WEF nexus issues.

In a subsequent group discussion, Dr Karlberg asked participants to discuss the main nexus issues in the Lake Urmia basin and to describe several scenarios that would be interesting to examine to better understand the impact of changes in the management of resources and/or the implementation of new technology. After this round, she showed the results of quantitative analysis and initial assessment projections for 2030 in Rwanda.

Dr Karlberg concluded that nexus analysis is not warranted in all cases and must be selective. Adaptation to local settings to reflect relevant issues is necessary. Last but not least, she emphasised that implementing a cross-sector process takes time.

Section 6: Collaborative Modelling and the Nexus Approach

The session on collaborative modelling was presented by two experts. **Mr Rudolph Cleveringa** (GWP) started the session with a general introduction to GWP describing it as a diverse, inclusive, multi-stakeholder partnership with 21 years of experience in pioneering and practising IWRM around the world. Water management is at the core of the challenges and opportunities of implementing most of the Sustainable Development Goals (SDGs) – from poverty reduction, hunger, health, gender equality, energy, economic growth, sustainable cities, climate action, biodiversity to peace. Managed well and sustainably, water will be a vital component for realising the 2030 Agenda. He gave the example of GWP in action, including on WEF and ecosystem nexus projects, urban water management, and transboundary water management.

Prof. Eelco van Beek (Deltares) focused on collaborative modelling for policy and decision making. Prof. van Beek stressed that "The Lake Urmia problem is complex. The whole system needs to be taken into account". He also listed buzzwords applicable to Lake Urmia, including IWRM, water security, inclusive, nexus thinking, ecosystem services, and climate change adaptation. He explained that a water resources system consists of three sub-systems: natural, socioeconomic, and institutional. These sub-systems should be taken into account in an integrated approach. Defining IWRM, he pointed out that IWRM is a process, not a goal in itself. IWRM is the means to reach water security. In defining water security, Prof. van Beek examined the criteria set out in the Asian Development Bank (ADB) Outlook 2016. ADB used five attributes to analyse and rank water security in Asian countries: household, economic, environmental and urban water security, and resilience to water-related disasters.

The next topic addressed by Prof. van Beek was collaborative modelling involving stakeholders in the analytical (modelling) work. Collaborative modelling should have four characteristics: a formal IWRM planning process, a structured collaborative process, a decision support system for water resources management, and a decision support system for negotiation.

Examples of successful collaborative modelling were described in the workshop. The first example was the shared vision planning for multiple interest negotiation in the Great Lakes, a water system shared between the US and Canada. The shared vision guides the development and selection of action plans under complex, multi-objective decision making and plans (Plan A+, Plan B+ and Plan D+) in the region. The participatory modelling approach to river basin planning in Büyük Menderes, Turkey, was the second case study presented by Prof. van Beek. The main objectives of this study are to identify measurable factors that influence ecological water quality, define clusters of water types, identify pressures, and formulate possible measures. Shared vision planning to operationalise IWRM in Peru was the third case study presented by Prof. van Beek.

Not all water resources studies consider the potential impacts of climate change. Prof. van Beek stressed that, given future uncertainties, the potential impacts of climate change are a key issue for collaborative modelling for planning. Fast, integrated, and dynamic are three requirements for models to support planning decisions under uncertainty. There are several benefits of collaborative modelling. According to Prof. van Beek, the benefits include: a common development agenda, which reduces disagreements among decision makers and stakeholders on future developments; enhanced trust and ownership of models and their outputs and strategies, which leads to a better understanding of the effectiveness of policy options; and, last but not least, collaborative learning for "decision making under uncertainty".

Explaining the collaborative modelling process, Prof. van Beek gave the example of the application of the Deltaplan process in Bangladesh. He concluded by saying that collaborative modelling for decision support is necessary because it builds acceptance and ownership. In addition, collaborative modelling improves understanding of systems and models. Collaborative modelling can also make both the modelling and decision-making processes more transparent and can encourage consensus on plans and strategies. Last but not least, collaborative modelling improves relations among stakeholders by fostering mutual understanding and allowing compromises to be negotiated. Finally, Prof. van Beek emphasised that problems around Lake Urmia are complex and include many nexus elements. This means it is necessary to involve stakeholders in the analytical work.

Section 7: Final Discussions

The Nexus Approach discussed during the meeting could not only be a sustainable way to integrate the management of environmental resources but, ultimately, could also be a way to achieve the SDGs. However, there are still many substantive concerns linked to new ideas and precisely what the Nexus Approach involves. Insights from integrated management of environmental resources indicate that the Nexus Approach needs to be tested in practice by implementing projects.

Inspired by the presentations of the experts invited to the workshop by UNU-FLORES, participants discussed the next steps in finding a nexus solution to the environmental problems faced by Lake Urmia. One possibility that was seriously debated was using wastewater for irrigation. "While the concept of a Nexus Approach was very well received, opinions were still very divided about the possibility of using treated wastewater as [an] alternative water source as a nexus solution," Prof. Hettiarachchi noted. "It is important for us to raise awareness about the Nexus Approach, and to advance the transfer of knowledge from scientific research to [the] policy and implementation sectors."

Through this international capacity development workshop, local experts gained a better understanding of the concept of the Nexus Approach and had a chance to share their region-specific knowledge on environmental issues. Based on the positive response of participants, the workshop organisers anticipate replicating such workshops in other countries and inviting more experts to help shape the discourse on the Nexus Approach. A summary of the interactive debate during the final workshop discussions is presented below.

1. Mexico City wastewater is transferred to the State of Hidalgo. For over a hundred years wastewater, combined with storm water, flowed into the Mezquital Valley in Hidalgo, benefitting agricultural activities and, at the same time, providing the metropolitan area with a solution to the disposal of its wastewater. However, after more than one hundred years, the Hidalgo area has the highest rate of cancer in the country. This case study showcases that wastewater has the potential to help water-stressed areas like the Lake Urmia region. However, it is crucial that water is first treated to ensure that it is safe so as not to jeopardise public and environmental health.

2. Wastewater treatment is expensive. Transferring treated wastewater to the Lake Urmia region faces practical difficulties. Using treated wastewater to fill the drying lake is an interesting idea. However, the treated wastewater would have to be transferred over a great distance and, even if the water reached the lake, the issue of the reduction in depth due to the formation of the salt bed would remain. Surface water just evaporates. There was a proposal to bring treated wastewater to Ajabshir City, adjacent to the lake, to culture Artemia (brine shrimp). However, the traditional water holders resisted the idea. They had been using the water for many years for producing vegetables, which they sold in markets. Environmental and economic assessments for wastewater treatment, and for transportation and energy to transfer treated wastewater to Lake Urmia need to be thoroughly investigated.

3. To use wastewater, we must raise awareness while taking cultural and religious factors into account. When people find out that the produce they buy has been irrigated with wastewater, they protest. This has happened in Sanandaj, Iran, where people boycotted local produce, especially vegetables irrigated with wastewater, and started buying vegetables from other cities.

4. For two decades, there has been a conflict in Isfahan, Iran, about the allocation of water. Interestingly, due to the water shortage, the conflict is now about the allocation of wastewater. Water scarcity alters values. Nonetheless, we need new standards for using wastewater in various sectors.

5. Can the minerals which are deposited in Lake Urmia, in salt, be a solution to its restoration? As sustainability costs money, the income from minerals could be a solution. It is worth mentioning that a foreign company proposed to extract minerals from the salts but were not able to proceed. The main environmental groups in Iran are against salt extraction since the lake is an area protected as a UNESCO Biosphere Reserve.

6. What is an appropriate solution to the current state of Lake Urmia? Certainly, we must accept the reality of the existing state of the lake. In the northern part we have billions of tonnes of salt, which contain minerals such as potassium magnesium and sodium chloride. These minerals are very expensive and could be used to generate billions of dollars for many years to come. Extracting minerals could create jobs for people. In the southern part, we should be able to bring Artemia production back to life by maintaining it in a separate area. This is the current situation and we must accept it. Keeping high hopes of saving the whole lake is futile.

7. We should add job creation to the nexus as this issue is important in Lake Urmia restoration. There is a trade-off between economic and environmental issues, and Lake Urmia is struggling between the two. The current political leadership wants to save the lake and, at the same time, increase employment in the region. However, with the increase in agriculture, irrigation, and energy production, there is no way to save the lake. We should select one of the two – agriculture or energy – without losing any more time, since time is running out for the survival of the lake. We should come up with solutions like salt extraction to compensate farmers. One of the constraints for mining minerals from the salts is the lack of sufficient markets.

8. When you define a place as a biosphere or a national park it meets many criteria. When a place no longer meets those criteria it means that it loses dignity as a national park. So, there is no problem with extracting salt as an option. The ULRP is looking for investors to extract the salts. The original size of the lake was 5,000 square kilometres, almost 10 per cent of the basin. Now ULRP is trying to restore almost 80 per cent of the lake, but even that cannot be achieved because ULRP has limited resources. So we are not sure what will happen to the remaining 20 per cent. Can the remaining 20 per cent be used for extracting minerals? On the other hand, ULRP never says "stop agriculture" but is trying to change the cropping pattern. Agriculture consumes almost 5 billion cubic metres (BCM) of water per year. Since we have about 500,000 hectares of fields, this means that a hectare consumes almost 10,000 cubic metres of water. This is too much and we have to reduce this to at least 5,000–6,000 cubic metres per hectare. With such a water-saving scheme we might be able to revive the lake.

9. Talking about the water-energy-food nexus, one of the main inputs we need is to know how much water is available in the basin. In the case of Lake Urmia there have been several debates on the quantity of annual renewable water. According to ULRP, the amount of water that is being used for agriculture is 5 BCM per year. But according to three other independent studies, for example, a study by the Japan International Cooperation Agency (JICA), it is around 2.4–2.7 BCM per year. There is a significant difference in estimates from different sources. Indeed, there is a big misunderstanding about water withdrawal and depletion as well. The amount depleted in the basin is around 2.5 BCM. The amount allocated to farmers may be about 8,000–10,000 cubic metres per hectare. But part of this water is returned to the system to be used again, so the amount of water used in agriculture in the basin is not as much as is assumed. Therefore, it is not possible to restore 80 per cent of the lake by changing irrigation systems or by any other means unless we restrict agriculture in some areas. SWAT modelling showed that water conservation by different methods would not release enough water for the lake.

10. Government investment in natural herbs that need very little water and generate a high return could be a simple way of reducing water consumption in the agricultural sector without creating new industries. Nevertheless, growing herbs would need education, promotion, and infrastructure for exports.

11. If farming must be reduced, the issues of livelihoods and jobs are tremendously sensitive. It may be wise to use Lake Urmia to supply water for alternative livelihoods. However, if 200,000 people lose their livelihoods as farmers, it would not be possible for Lake Urmia to sustain jobs for so many people.

12. The maximum temperature in West and East Azerbaijan in recent years has increased by 1–2 degrees Celsius over the historical average. Therefore, we should consider global warming and its effect on our future.

13. Lake restoration requires good governance. Based on nexus thinking, it is urgent to create an integrated organisation, stronger than ULRP, to unify the interventions to solve this problem. In the past, there have been parallel interventions that have resulted in a loss of trust between organisations and farmers.

14. Changing the crop pattern is not like changing the technology. It is a different, long-term process. To change the crop pattern, it really takes a long time to convince farmers to change from one, probably very traditional, crop to a new one. Changing the crop pattern does not simply mean buying different seeds for the next season; it means also that farmers have to be convinced that the new option is also economically viable. These processes to convince farmers need plenty of time and cannot be regarded as simply switching from one crop to another.

15. If we want to implement approaches like the nexus, firstly, we need to think about how to implement these approaches in local contexts. The Nexus Approach, or any other approach, does not necessarily work in a country just because it worked in other parts of the world. So, the first step after identifying the best approach and best practice is to engage in collaborative modelling to find which model is useful for the region or country.

16. Iran is a country with social, cultural, economic, and religious differences even within a basin like Urmia. So, how should the various sectors cooperate? The essence of this question is that society is too broad and too complex for a nexus kind of approach. The basin is what brings the different agents in different sectors of society together.

17. How do we achieve a shared vision between decision makers and scientific institutions? Understanding the trade-offs is also another gap: If we want to restore Lake Urmia it is important to understand that we cannot make everybody happy.

18. Sustainable development will not ever progress if you start with a preconceived idea of winners and losers. We must make tough decisions about trade-offs to achieve the larger benefits. The solutions need to be presented to people at every step, not just at the initial step. This requires a lot of trust building, transparency, and accountability, which can be a challenge for society as a whole.

19. The issue is not about water; it is about people and, particularly, about socioeconomic relations. And, the ultimate solution would not be to work on water but to work on improving socioeconomic relations. The government must give people, particularly farmers, some livelihood alternatives before reducing their water rights. And, other ministries, such as the Iran Ministry of Economic Affairs and Finance, should be involved in finding livelihoods for farmers so that ULRP can focus on solving the problem of Lake Urmia.

20. Science diplomacy can be a tool to enhance trust and peace between countries. It also helps to get to the bottom of the issues from a scientific perspective. This workshop, initiated by UT by inviting UNU-FLORES to explore nexus thinking, is an excellent example of such a step.

ANNEX LIST

Appendix 1: Field Visit

Participants had the opportunity to join a field visit on Day 1 of the programme. The field visit included stops at the Ajichai River, Tabriz Thermal Power Plant, and Lake Urmia. Some of the interesting aspects captured around Lake Urmia are posted below.

Appendix 2: Programme Highlights

Venue: Laal Hall, Faculty of Electrical and Computer Engineering, University of Tabriz

Day	Session	Time	Coverage
Day 1 (Sunday, 12 November 2017)	**Brief welcome by University of Tabriz**	8:30–10:00	Presentation by local experts: Lake Urmia and other environmental issues › Prof. Naser Agh, *University of Urmia* › Dr Ali A. Alamolhoda, *Sharif University of Technology* › Prof. Saeed Morid, *Tarbiat Modares University*
		10:00–10:30	*Coffee break and networking*
	Field visit	10:30–18:00	Mehranrud River, Tabriz Power Plant, and Urmia Lake, and a few stops in between
Day 2 (Monday, 13 November 2017)	**Registration**	8:00–8:30	
	Inaugural session	8:30–10:00	National anthem and religious observations Welcome speeches › Prof. Mohammad Reza Pour Mohammadi, *Chancellor, University of Tabriz* › Prof. Kaveh Madani, Vice-Chair, *Iran Department of Environment* › Dr Mohammad Fazeli, *Advisor to Minister of Energy, Iran* Prof. Hiroshan Hettiarachchi, *UNU-FLORES*: Role of Waste in the Nexus Group picture
		10:00–10:30	*Coffee break and networking*
	Session 1: Evolution of the concept	10:30–12:15	Brief history of the development of nexus thinking (Dr Fritz Holzwarth, *formerly UNESCO-IHE*) Adaptation of the concept to local settings (Dr Louise Karlberg, *SEI*)
		12:15–13:45	*Lunch and networking*
	Session 2: Modelling and the paradigm shift	13:45–15:30	Collaborative modelling and the nexus (Mr Rudolph Cleveringa, *GWP/ Prof. Eelco van Beek, Deltares*)
		15:30–16:00	*Coffee break and networking*
	Session 3: What next?	16:00–17:30	Panel discussion/Q&A attended by all contributors (Moderator: Prof. Hiroshan Hettiarachchi)
	Conclusion	17:30–18:00	

Appendix 3: International Team of Experts

in alphabetical order

Prof. Naser Agh
Urmia University (UU)
Urmia, Iran

Naser Agh is an Associate Professor in the departments of Biology, Ecology and Aquaculture, Urmia University (UU). He founded the Artemia and Aquatic Animals Research Institute at UU in 1998. He obtained his BSc and MSc degrees from the M.S. University of Baroda, India, in Zoology and Microbiology and his PhD from the University of Ghent, Belgium, in Applied Biological Sciences. His research interests include Ecology, Biology and Aquaculture. He has been working on Lake Urmia ecology and biodiversity, especially on the brine shrimp Artemia urmiana since 1995. Dr Agh has led many national projects and has represented the Middle East and Central Asian countries in an international project on Artemia biodiversity funded by the European Commission. He is recognised by FAO as an international scientist leading research programmes on Artemia in Western Asia.

Prof. Ali A. Alamolhoda
Sharif University of Technology
Tehran, Iran

Ali Alamolhoda is the Director of the Institute for Water and Energy at Sharif University of Technology in Tehran. He has also been the Secretary of the Water Committee at the Technology Development Council for Water, Drought, Erosion and Environment, Vice-Presidency for Science and Technology of Iran since 2013. Formerly he was a vice-director in charge of the Technical and Industrial Division for the managing director of the Moghan Agro-Industry and Livestock Company, Ardabil, Iran (1993–1997). He was a private consultant (1992–1989) providing services for air quality monitoring in the Tehran Municipality and other industries. He was a postdoctoral fellow (US EPA grant) working (1987–1989) in the Department of Chemical Engineering, University of Akron, Ohio (USA) after earning his PhD and MSc in Analytical Chemistry and Polymer Science. He earned his BS degree in Applied Chemistry from the Sharif University of Technology, Tehran, Iran, in 1977.

Mr Rudolph Cleveringa
Global Water Partnership (GWP)
Stockholm, Sweden

Rudolph Cleveringa, of Dutch origin, has a degree in agricultural engineering from Wageningen University in The Netherlands and over 35 years of global experience and engagement in various aspects of development ranging from operational land, water and rural infrastructure projects to programme and policy advisory work. He has broad experience working in collaborative partnerships, engaging with SIWI, UN-Water, CGIAR, FAO and many other organisations. He has managed both large units and small project teams across diverse cultures and disciplines. Mr Cleveringa currently holds the position of Executive Secretary of GWP. Before joining GWP he was a Senior Technical Advisor for Rural Development, Water and Rural Infrastructure at the International Fund for Agricultural Development (IFAD).

Prof. Hiroshan Hettiarachchi
United Nations University (UNU-FLORES)
Dresden, Germany

Hiroshan Hettiarachchi heads the Waste Management Unit at UNU-FLORES. His background is in civil engineering and he has conducted research and published extensively in the areas of geotechnical and geoenvironmental engineering and sustainable waste management. His recent work focuses on sustainable environmental resources management, which has resulted in a number of scientific and capacity development workshops in Asia, Africa and South America on Safe Use of Wastewater in Agriculture (SUWA), which is considered to be one of the golden examples of the Nexus Approach. He is also an expert in graduate programme development and took the lead in developing the joint PhD programme in Integrated Management of Water, Soil and Waste offered by UNU-FLORES, in partnership with Technische Universität Dresden. Prior to joining UNU, he was at the Lawrence Technological University in Michigan, USA.

Dr Fritz Holzwarth
(formerly at UNESCO-IHE)
Bonn, Germany

Fritz Holzwarth was the rector of UNESCO-IHE until his recent retirement. His background is in economics, law, political science and business administration. Before joining UNESCO-IHE he held various positions during his long and successful career in Germany. One of his notable contributions was the initiation of the Bonn 2011 Conference together with the German Ministry for Economic Development, which paved the way to the ongoing dialogue on the Water, Energy and Food Security Nexus. His previous professional responsibilities were, inter alia, Head of the German Delegation of the Baltic Marine Environment Commission (HELCOM), Head of the German Delegation for the Protection of the Marine Environment of the North-East Atlantic (OSPAR), Head of the German Delegation for International Commission for the Protection of the Danube River (ICPDR), Head of Delegation and later President of the International Commission for the Protection of the Rhine (ICPR) and President of the International Commission for the Protection of the River Elbe.

Dr Louise Karlberg
Stockholm Environment Institute (SEI)
Stockholm, Sweden

Louise Karlberg is Centre Director, SEI, Stockholm. She has over 15 years of professional experience in research on the environment and development. Her work covers a broad range of topics, from local level studies on agricultural water management interventions to global water assessments. Several of her projects have investigated resource requirements and constraints for agricultural transformation and energy transitioning in sub-Saharan Africa to support planning and policymaking. Dr Karlberg's projects have predominantly been located in low-income countries and have combined numerical modelling with participatory methods. She holds an MSc in Systems Ecology from Stockholm University and a PhD in Land and Water Resources Engineering from the Royal Institute of Technology (KTH), Sweden. She has published over 40 scientific papers, book chapters, reports, briefs and popular science articles.

Prof. Saeed Morid
Tarbiat Modares University (TMU)
Tehran, Iran

Saeed Morid is a Professor at Tarbiat Modares University (TMU), Department of Water Resources Engineering. Before joining TMU, he was general manager of the water consulting engineers affiliated to the Ministry of Energy, Iran. He received his PhD in Water Resources Management from the Indian Institute of Technology, Delhi, India. His research interests include drought, climate change and integrated modelling of water resources systems. Prof. Morid has led many national and international research projects, including Drought Assessment and Mitigation in Southwest Asia (IWMI-USAID), National Strategy and Action Plan on Drought Preparedness, Management and Mitigation in the Agricultural Sector (FAO and Iranian Ministry of Agriculture), Challenge Program on Water and Food (ICADAR- World Bank), and Drought Risk Management of Lake Urmia Basin (CIWP-UNDP).

Prof. Eelco van Beek
Deltares/Global Water Partnership (GWP)
Delft, The Netherlands

Eelco van Beek is an expert in integrated water resources management (IWRM) who has worked on the interface between IWRM research and its application in the field, and has been involved in implementing IWRM in many countries, including Iran. During the nearly 45 years of his professional career, Prof. Van Beek has been actively involved in many water resources development projects, ranging from projects emphasising long-term planning to real-time operational projects, pre-feasibility studies to detailed water management projects, and integrated studies (water quantity, water quality, ecology, economics, socio-economics and institutional aspects) to single-aspect studies. He has also served as a professor at Delft University of Technology and the University of Twente. Currently he serves as the Vice-Chair of the Technical Committee of Global Water Partnership (GWP) while working as water resources management specialist at Deltares (formerly WL | Delft Hydraulics).

Appendix 4: List of Attendees

who received a certificate of completion issued by the University of Tabriz

No.	First Name	Last Name	Position	Affiliation
1	Naser	Agh	Associate Professor	University of Urmia
2	Akram	Ahmadzadeh	Secretary of the Environmental Society / Medical Student	Urmia Medical Science University
3	Ali Asghar	Alamolhoda	Director of Institute for Water and Energy	Sharif University of Technology
4	Amin	Amanat	MSc Student	University of Tabriz
5	Zahra	Atafar	MSc Student	Tehran University of Medical Sciences
6	Mehdi	Babayi	Vice-Chair	Tehran Province Water and Wastewater Company
7	Aida	Bagheri Basmenji	MSc Student	University of Tabriz
8	Rudolph	Cleveringa	Executive Secretary	GWP
9	Ghofran	Cheraghi	Water Resource Expert	Behkar Ab Ahwaz Engineering Company
10	Parisa	Dolatimehr	MSc Student	University of Tabriz
11	Zeynab	Eslami	MSc Student	Guilan University
12	Eslam	Eslami	Undergraduate Student	University of Tabriz
13	Armin	Farshbaf	MSc Student	University of Tabriz
14	Mehdi	Fasihi Harandi	Instructor of Water Diplomacy and Governance	University of Tehran
15	Peyman	Fathi Rezayi	Regional Water Authority Agent	Urmia Lake Restoration Program
16	Mohammad	Fazeli	Advisor to Minister of Energy	Ministry of Energy, Iran
17	Hojjat	Fouladi	PhD Candidate	University of Tabriz
18	Sahand	Ghadimi	Student	Tarbiat Modares University
19	Farhood	Hashemi	MSc Student	University of Tabriz
20	Sayed Mukhtar	Hashemi	Associate Researcher	Newcastle Institute for Sustainability
21	Gholam Reza	Hashemi	Managing Director	East Azarbaijan Regional Water Authority
22	Mir Asghar	Hashemi Ranjbar	Managing Director	Bamsaz Company
23	Yousef	Hassanzadeh	Professor	University of Tabriz

No.	First Name	Last Name	Position	Affiliation
24	Fritz	Holzwarth	Former Deputy Director-General	Water Management, German Federal/ UNESCO-IHE
25	Alireza	Imanloo	Managing Director	East Azarbaijan Province Water and Wastewater Co.
26	Nardin	Jabbarian Paknezhad	MSc Student	University of Tabriz
27	Mojtaba	Jalilzadeh	Vice-Chair	East Azarbaijan Regional Water Authority
28	Mahdi	Javadi	Student	University of Tabriz
29	Maryam	Javan Salehi	MSc Student	University of Tabriz
30	Louise	Karlberg	Centre Director	Stockholm Environment Institute (SEI)
31	Malihe	Keykhaee	Researcher	Isfahan University of Technology
32	Mohammad	Kobarfard	PhD Candidate	Sari Agricultural Sciences and Natural Resources University
33	Kaveh	Madani	Vice-Chair	Iran Department of Environment
34	Fariborz	Masoumi	Assistant Professor	University of Mohaghegh Ardabili
35	Sina	Masoumzadeh	MSc Student	University of Tabriz
36	Hojjat	Mianabadi	Assistant Professor	Tarbiat Modares University
37	Mohammad	Moghaddam Vahed	Vice-Chancellor	University of Tabriz
38	Behshad	Mohajer Iravanloo	PhD Candidate	Tehran Science and Research University-IAU
39	Saeed	Morid	Professor	Tarbiat Modares University
40	Mir Mohsen	Mousavi	Secretary of The Strategic Committee of Urmia Lake in the Agricultural Sector	East Azarbaijan Agriculture Jihad Organisation
41	Saman	Narvani	MSc Student	University of Tabriz
42	Sasan	Narvani	MSc Student	University of Tabriz
43	Ebrahim	Nazlabadi	PhD Candidate	Amirkabir University of Technology
44	Milad	Nejati	Technical Assistant / Urmia Lake Restoration Program	Japan International Cooperation Agency
45	Davood	Nour Mohammadi	Manager of Sustainability Office	Tehran Province Water and Wastewater Company
46	Mojtaba	Nouri	Research Manager	Iran Water Resource Management Company

No.	First Name	Last Name	Position	Affiliation
47	Farhad	Paknia	Director of Public Participation	East Azarbaijan Regional Water Authority
48	Ehsan	Pashanejad	Research Assistant	University of Tabriz
49	Yavar	Pour Mohammad	PhD Candidate	Ferdowsi University of Mashhad
50	Mohammad Reza	Pour Mohammadi	Chancellor	University of Tabriz
51	Nima	Pour Nabi	MSc Student	Guilan University
52	Mehrdad	Pouya	PhD Candidate	Buali Sina University
53	Reza	Rahbar	MSc Student	University of Tabriz
54	Shima	Rahim Pouran	Postdoctoral Fellow	University of Tabriz
55	Mohammad Hossein	Rezaei Moghaddam	Professor	University of Tabriz
56	Amin	Rostami	PhD Candidate	Sari Agricultural Sciences and Natural Resources University
57	Vahideh	Safaee	MSc Student	Ferdowsi University of Mashhad
58	Soheil	Safari	MSc Student	University of Tabriz
59	Shabnam	Salman Taleshi	MSc Student	Guilan University
60	Behnam	Sami	MSc Student	University of Tabriz
61	Mohammad Hossein	Sarrafzadeh	Associate Professor	University of Tehran
62	Hossein	Shahbaz	Director of International Office	Urmia Lake Restoration Program
63	Mahdi	Shahsavar Javadi	Undergraduate Student	University of Tabriz
64	Habib	Shayanfar	Distinguished Expert	Agricultural Engineering Organisation
65	Arash	Taghipour Zarei	Undergraduate Student	University of Tabriz
66	Mahdi	Taraghi	PhD Candidate	Isfahan University of Technology
67	Omid	Tavakoli	Assistant Professor	University of Tehran
68	Faranak	Tootoonchi	PhD Candidate	Amirkabir University of Technology
69	Parisa	Valizadeh	MSc Student	University of Tabriz
70	Eelco	van Beek	Professor	Deltares/GWP
71	Morteza	Yeganeh	Student	Birjand University
72	Afshin	Yousef Gomrokchi	Postdoctoral Fellow	Qazvin Agriculture Research Centre
73	Soheil	Zafaranchi	MSc Student	University of Tabriz
74	Mahdi	Zarghami	Professor	University of Tabriz

Appendix 5: Local Organising Team

in alphabetical order

- Amin Amanat
- Mahdi Asadian
- Eslam Eslami
- Dr Mahdi Fasihi Harandi
- Hojjat Fouladi
- Maryam Javan Salehi
- Heydar Khodai
- Mohammad Kobarfard
- Sina Masoumzadeh
- Javad Mosadegh
- Saman Narvani
- Sasan Narvani
- Milad Nejati
- Naser Nemati
- Reza Rahbar
- Behnam Sami
- Mahdi Shahsavar Javadi
- Arash Taghipour Zarei
- Amir Tavanafar
- Asghar Teimori

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The United Nations University Institute for Integrated Management of Material Fluxes and of Resources (UNU-FLORES) was established in Dresden, Germany in 2012 with the support of the Federal Ministry of Education and Research (BMBF) and the Ministry for Higher Education, Research and the Arts (SMWK) of the Free State of Saxony, Germany. As part of the United Nations University (UNU), the Institute helps build a bridge between the academic world and the United Nations. UNU encompasses 13 research and training institutes and programmes located in 12 countries around the world. UNU as a whole aims to develop sustainable solutions for pressing global problems of human survival and development.

UNU-FLORES develops strategies to resolve pressing challenges in the area of sustainable use and integrated management of environmental resources such as water, soil, and waste. Focusing on the needs of the UN and its Member States, particularly developing countries and emerging economies, the Institute engages in research, capacity development, advanced teaching and training, as well as dissemination of knowledge. In all activities, UNU-FLORES advances a Nexus Approach to the sustainable management of environmental resources.

Find more information at: **flores.unu.edu**

ADVANCING A NEXUS APPROACH TO THE SUSTAINABLE MANAGEMENT OF ENVIRONMENTAL RESOURCES

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