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Reconciling resource uses in transboundary basins: assessment of the water-food-energy-ecosystems nexus

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Reconciling resource uses in transboundary basins: assessment of the water-food-energy-ecosystems nexus

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FOREWORD

Coordination between the water, energy, food and environment sectors is challenging even at the national level. But the complexity increases substantially in transboundary river basins where the impacts spread from one country to another and trade-offs and externalities may cause friction between the riparian countries. The "nexus approach" to managing interlinked resources has emerged as a way to enhance water, energy and food security by increasing efficiency, reducing trade-offs, building synergies and improving governance, while protecting ecosystems.

Despite the increasing recognition of the importance of interlinkages and dependencies between sectors, the nexus approach commonly remains abstract or at the level of political statements. Work on the nexus at the transboundary level is very rare. *Reconciling resource uses in transboundary basins: assessment of the water-food-energy-ecosystems nexus* explores new ground by applying a systematic approach to determine what is entailed in the water-food-energy-ecosystems nexus in transboundary basins. On the basis of a practically-oriented and participatory assessment, this work shows the tangible benefits of intersectoral coordination and transboundary cooperation.

Carried out in the framework of the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention), with the leadership of Finland, the assessment of the water-food-energy-ecosystems nexus aims to promote transboundary cooperation by identifying intersectoral synergies that could be further explored and utilized, and determines policy measures and actions that could alleviate tensions or conflicts related to the multiple uses of and needs for common resources. The nexus assessment is also intended to assist countries in optimizing their use of resources, to increase efficiency and to ensure greater policy coherence and co-management. To this end, the methodology developed for the assessment is applicable to very different basins with very different conditions, providing a framework flexible enough for global use and yet adapting to specific conditions and issues at stake.

The results underline the significance of intersectoral issues and the scale of the challenges. With the projected growth in needs, ensuring food and energy security, without overexploiting water resources and compromising the integrity of ecosystems, will require cooperation and integrated planning. The invitation to break the silos by managing beyond single sectors carried by this assessment is particularly timely in the light of the recently adopted 2030 Agenda for Sustainable Development. To meet the objectives of this ambitious agenda, policies and measures will need to support progress towards several Sustainable Development Goals and many targets in a synergetic and mutually supportive manner. The nexus assessment shows that, with transboundary cooperation, it is possible to achieve the sustainable management of water resources and, at the same time, increase the share of renewable energy sources and agricultural productivity.

If the level of the challenges is high, so is the diversity of possible actions: the nexus assessment highlights that there are many opportunities to seize through joint action. It shows that it is possible to reconcile development and the protection of the environment and that it makes good economic sense to be resource efficient and look for synergies.

I hope that the nexus assessment will trigger action and new partnerships across borders and sectoral lines and that the methodology will find wider application and support among countries desiring to cooperate so as to optimize the use of their resources and ensure greater policy coherence.

Christian Friis Bach

Executive Secretary
UNECE

PREFACE

The assessment of resources is of fundamental importance as it forms the basis for rational planning and decision-making by Governments. In transboundary settings, it becomes even more crucial as it underpins cooperation. This is why the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) requires its Parties to carry out, at regular intervals, joint or coordinated assessments on the condition of transboundary waters and the effectiveness of measures taken for the prevention, control and reduction of transboundary impacts. The Water Convention has been promoting joint assessment of transboundary waters since the early 2000s, including regional assessments.

The *Second Assessment of Transboundary Rivers, Lakes and Groundwaters*, published in 2011, showed evidence of frequent intersectoral frictions in shared basins and highlighted a lack of coherence in the sectoral policies in the pan-European region. To respond to these challenges, the Meeting of the Parties to the Water Convention decided in 2012 to carry out an assessment of the water-food-energy-ecosystems nexus in selected transboundary basins. In practice, addressing the nexus means finding a balance between the various uses and the protection of the resource for sustainability, as well as managing the trade-offs and increasing synergies. Cooperation and dialogue are therefore key if intersectoral conflicts are to be managed effectively at a transboundary scale and if the objectives of the Convention — to reduce transboundary impacts and to use transboundary waters in a reasonable and equitable way — are to be fulfilled.

Despite the emerging recognition of the importance of intersectoral impacts affecting water, food and energy security, little has been done about the nexus at the transboundary level. Consequently, a lot of experimentation was necessary when exploring these uncharted waters. This pioneering work on transboundary nexus assessment received great interest and support from the international community in the course of its development, including from the High-level Political Forum on Sustainable Development in 2014.

A nexus assessment methodology was developed specifically for this process under the Task Force on the Water-Food-Energy-Ecosystems Nexus, established by the Parties to the Convention to oversee the assessment. The piloting of the methodology in the Alazani/Ganykh Basin and the subsequent assessments in the Sava and the Syr Darya Basins made it possible to iteratively "learn by doing", and led to the progressive improvement of the methodology. The highly participatory approach focused the study on the jointly identified priority nexus issues, progressing logically towards outlining possible solutions, that is, possible synergic response actions. The Task Force brought together the representatives of the countries concerned by the basin assessments as well as partners and experts to develop the assessment and review the findings. While the aim was to develop a technically sound way to assess the nexus, emphasis was placed on participation and the mobilization of insights from local officials, stakeholders and experts, with more than 200 people participating in the process.

Pragmatically speaking, the assessment is not calling for specific "nexus" governance, but rather it encourages the use of existing intersectoral mechanisms and structures so as to advance towards more integrated planning and greater coordination. Also, from the point of view of solutions and the way forward, the message is as concrete and pragmatic as possible. A lack of full certainty should not prevent responses from being implemented. Addressing one part of a complex nexus (irrespective of the exact sectors involved) with even a partial solution is still a step forward. A nexus assessment thus helps to pose or refine the right policy questions.

A nexus assessment forces us to look ahead into our future. It is not enough to assess the nexus in terms of what it means in the present time, but it is essential to consider what climate variability and change as well as socioeconomic trends mean for intersectoral dynamics in a couple of decades. The outlook may mean that agricultural production cannot be as water-intensive as it used to be, while climate policies and environmental regulation may place specific constraints on developing energy regulation.

Engaging the agriculture and energy sectors into a truly intersectoral assessment proved to be among the main challenges of the process. In analysing links between the resources, as well as in reaching out to the sectors concerned, this exercise benefitted from the expertise of the Food and Agriculture Organization of the United Nations (FAO) on agriculture and land management, the insights of the United Nations Economic Commission for Europe (UNECE) Environment Division and information collected by the Environmental Performance Reviews. The availability of good, accurate, harmonized and up-to-date data and information has been another challenge.

The resulting assessments demonstrate that there are many common challenges that play out in unique ways, depending on the history and status of cooperation that riparian countries share. The solutions are also context-specific to a certain degree. Nevertheless, lessons can (and should) be learned from the experiences in other basins or other countries. Not all the riparian countries sharing the assessed basins were equally keen to participate, but they have all nonetheless contributed towards serving valuable and concrete lessons. It is clear that the sectoral interests at stake are a sensitive issue. Reconciliation and better accommodation of different water uses of the same resource are possible, but require a willingness to explore and think about differing perspectives.

The nexus assessment methodology that has been developed and tested is a generic one that adapts to the issues at stake. In the future work under the Convention, it is planned to replicate this exercise in other basins and — in keeping with the opening of the Water Convention to all United Nations Member States — interest in applying the methodology has been expressed by different regions of the world from very different countries: both developed and developing, water scarce and water rich. Further work, including focusing on specific issues, is clearly needed and it will be interesting to take stock of assessing the nexus also from other areas of the globe where substantive work on the water-food-energy-ecosystems nexus has been carried out.

This nexus assessment was made possible by the diverse expertise and broad participation that it engaged. I would like to warmly thank all the country officials and experts for their invaluable contributions. I would also like to thank the many partners that supported the work: FAO; the Swedish Royal Institute of Technology; the Global Water Partnership; the International Sava River Basin Commission; the Zoï Environment Network, the United Nations Development Programme's (UNDP) Global Environment Facility (GEF) funded project "Reducing Transboundary Degradation in the Kura Araks River Basin"; and the Joint Research Centre of the European Commission. Finally, I would like to thank the Governments of Finland, Germany, Italy and Switzerland for their financial support to the nexus assessment. And last, but not least, many thanks to the UNECE secretariat for which this was a complex undertaking, with very special thanks to Annukka Lipponen, the coordinator, for her dedication and hard work.

Seppo Rekolainen

Chair of the Task Force on the Water-Food-Energy-Ecosystems Nexus

Director of the Freshwater Centre at the Finnish Environment Institute

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A

Mansur Abduraimov
Mutallim Abdulhasanov
Aigul Absametova
Dilshodbeg Ahmadov
Abbos Akhadov
Ittifok Akhmedov
Arif Akhundov
Giorgi Akhvlediani
Enes Alagic
Adishirin Alakbarov
Natalia Alexeeva
Fariz Aliyev
Zakir Aliyev
Paolo Angelini
Otar Antia
Matanat Avazova

B

Akhaverdi Badalov
Ivana Bajković
Joldoshbek Bajyzbekov
Sandro Bakanidze
Tilkyn Balpikov
Bogdan Barbič
Eliso Barnovi
Ines Beernaerts
Iskander Beglov
Sopho Beridze
Andrea Bianchini
Aleš Bizjak
Momcilo Blagojevic
Giorgi Bokeria
Darko Borojević
Merita Borota
Petra Brandelek
Irena Brnada
Mitja Brilly

C

Andro Chachanidze
Aleksandra Drobac Čik
Nataša Crnković
Jean Abdias Compaore
Gorana Ćosić-Flajsig
Massimo Cozzone
Gabriela Cretu
Katharine Cross
Elizabeth Curmi

D

Ali Dakiche
James Dalton
Irina Davis
Pavle Davitashvili
Nickolai Denisov
Ruslan Devyatkulov
Stamaliev Diamond
Nurzhamal Dosova
Aleksandar Dragišić
Abdybai Dzailoobaev
George Dzamukashvili
Nenad Đukić
Neven Duić
Nataša Đereg
Dragana Đukić
Irma Popović Dujmović

E

Tatiana Efimova
Henri-Claude Enoumba

F

Dimitris Faloutsos
Tracy Farrell
Arduino Freschi
Hassen Lotfi Frigui

G

Gela Gelashvili
Simona Getova
Shalva Giorgadze
Gianpaolo Giugovaz
Lidija Globevnik
Jakob Granit
Samo Grošelj
Goran Gugić
Tyngyshbayeva Gulbanu
Nino Gvazava

H

Socheat Hak
Sahib Hasanzade

I

Sagit Ibatullin
Rope Imanaliev
Furkat Irmatov
Tilek Isabekov
Leyla Isayeva
Rashail Ismayilov
Rafig Ismayilov
Zdenka Ivanović

J

Rahman Jalilov
Heide Jekel
Silvester Jeršič
John Joyce
Ita Juroš

K

Mihaela Kadija
Ramiz Kalbiyev
Pasha Karimov
Adilkhan Adilhan Karlikhanov
Marko Keskinen
Ivana Kesten
Salome Khachauri
Bahri Khalili
Nazarov Kholmakhmad
Daler Kholmatov
Lyudmila Kiktenko
Anoulak Kittikhoun
Jože Klemenčič
Verena Klinger-Dering
Irakli Kobulia
Dejan Komatina
Stanka Koren
Aleksandra Kovačević
Nicole Kranz
Miroslav Kukobat
Tarik Kupusović
Sharif Kuchkarov

L

George Lashkhi
Djamel Latrech
Xavier Leflaive
Harry Liiv
Aizo Lijcklama
Elena López Gunn

M

Nino Machitadze
Raimund Mair
Mariam Makarova
Bekbolot Mamatairov
Rasim Mammadov
Aynur Mammadova
Miroslav Marković
Mulloev Maruf
Jelena Marojević-Galić
Lucija Marovt
Alexander Martussevich
Mary Matthews
Seth McNayr
Nataša Milić
Dragana Milovanovic
Miodrag Milovanovic
Alexander Mindorashvili
Giovanni Munoz
Kasiet Musabayev

N

Lydia Nikiforova
Alexander Nikolayenko
Lesya Nikolayeva
Hong Phuong Nguyen
Viktor Novikov
Karim Nuraliev

O

Teymur Osmanov

P

Tatiana Pasquel
Livia Peiser
Igor Petrakov
Marija Pinter
Blaž Pišek
Jasna Plavšić
Oleg Podolny

R

Tatijana Rakočević

Seppo Rekolainen (Chair of the Task Force on the Water-Food-Energy-Ecosystems Nexus)

Moncef Rekaya
Petra Remeta
Ana Katila Ribeiro

S

Tobias Salathe
Tulegen Sarsembekov
Ilyashbek Sarybaev
Rasim Sattarzada
Susanne Schmeier
Peter Schutte
Azizbayov Shahlo
Jemal Shalashvili
Nina Shatberashvili
Nurmahamad Sheraliev
Mariam Shotadze
Aleksandra Šiljić
Slobodan Simić
Otto Simonett
Svetlana Šivarëva
Gordana Špegar
Pasquale Steduto
Thomas Stratenwerth
Ekaterina Strikileva
Tatyana Suchkova
Kakha Sukhitashvili
Akylbek Sulaimanov
Dragan Šulović
Bedoriev Sunatulo
Dejan Supić

T

Naida Taso
Irakli Todria
Minh Khoi Tran
Badri Tsatava

U

Baadur Ukleba
Giorgi Urbekhashvili

V

Timur Valamat-Zade
Jalaladdin Valiyev
Anvari Vajsiddin
Frank van Weert
Zaza Vardoshvili
Frederik Verhoog
Sibylle Vermont
Jovan Vukadinović
Nikola Vukotić

Y

Rauf Yuldashev

Z

Ivan Zavadsky
Dragan Zeljko
Dinara Ziganshina
Denis Žiško
Muslim Zhiyenbaev
Nataša Žugić-Drakulić
Zrinko Zvocak

Local experts

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English editing:
Cathy Lee and Amy Edgar (UNECE).

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UNECE

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LIST OF COUNTRY CODES

AZ	Azerbaijan
BA	Bosnia and Herzegovina
GE	Georgia
HR	Croatia
KG	Kyrgyzstan
KZ	Kazakhstan
ME	Montenegro
RS	Serbia
SI	Slovenia
TJ	Tajikistan
UZ	Uzbekistan

ACRONYMS AND ABBREVIATIONS

ADB	Asian Development Bank
CAP	Common Agricultural Policy
CAPS	Central Asian Power System
CDC	Coordinating Dispatch Centre
CIS	Commonwealth of Independent States
CLEW	Climate, Land-use, Energy and Water
EDB	Eurasian Development Bank
EIA	Environmental Impact Assessment
ENVSEC	Environment and Security Initiative
EPR	Environmental Performance Review
EU	European Union
EU WI	European Union Water Initiative
FAO	Food and Agriculture Organization of the United Nations
FASRB	Framework Agreement on the Sava River Basin
FEWS	Food-Energy-Water-Security
GEF	Global Environment Facility
GHG	Greenhouse Gas
GIS	Geographical Information System
GWP	Global Water Partnership
IAEA	International Atomic Energy Agency
ICPDR	International Commission for the Protection of the Danube River
ICWC	Interstate Commission for Water Coordination
IFAS	International Fund for Saving the Aral Sea
IPCC	Intergovernmental Panel on Climate Change
IPPC	Integrated Pollution Prevention and Control
ISRBC	International Sava River Basin Commission
IUCN	International Union for Conservation of Nature
IWA	International Water Association
IWRM	Integrated Water Resources Management
JRC	Joint Research Centre, European Commission
KTH	Royal Institute of Technology, Stockholm
NGO	Non-governmental organization
OECD	Organisation for Economic Co-operation and Development
OSCE	Organization for Security and Co-operation in Europe
RES	Renewable energy sources
SEA	Strategic Environmental Assessment
SIC ICWC	Scientific-Information Center of the Interstate Coordination Water Commission of Central Asia
SLM	Sustainable Land Management
UNDP	United Nations Development Programme
UNDESA	United Nations Department of Economic and Social Affairs
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
WUA	Water user association
WFD	Water Framework Directive, i.e. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy

UNITS OF MEASURE

a.s.l.	Above sea level
BTU	British Thermal Unit
CO_2	Carbon dioxide
GW	Gigawatt
GWh	Gigawatt-hour
h	Hour
ha	Hectare
km^2	Square kilometre
km^3	Cubic kilometre
km	Kilometre
kW	Kilowatt
m^3	Cubic metre
MW	Megawatt
s	Second
°C	Degree Celsius

CHAPTER 1
Introduction and background to the nexus assessment

The water, energy and food sectors are so strongly interlinked that actions in one area commonly impacts on one or both sectors. Yet all too often these sectors operate in isolation, and seeking security in one sector may in fact compromise others. The international conference on The Water, Energy and Food Security Nexus – Solutions for the Green Economy (Bonn, November 2011) brought greater attention to these interlinkages and presented initial evidence on how a nexus approach can enhance water, energy and food security by increasing efficiency, reducing trade-offs, building synergies and improving governance across sectors.

Since the Bonn conference the nexus of particular sectors or components has been variably defined depending on the scope and focus of each study or project, and deviating from the classic nexus of the three sectors referred to above. Some definitions, for example, include climate as a part of the nexus.

The nexus needs to be tackled in practice across diverse physical and political settings, including in the context of transboundary river basins in which little has been done so far. At its sixth session (Rome, 28–30 November 2012), the Meeting of the Parties to the United Nations Economic Commission for Europe (UNECE) Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) decided that an assessment of the water-food-energy-ecosystems nexus of a representative set of transboundary basins would be carried out as a part of the programme of work under the Convention for 2013–2015.

When the Parties to the Water Convention decided to carry out an assessment on the nexus, ecosystems were included in the scope of the nexus, as it was felt that environmental aspects had not received sufficient attention in earlier nexus work.

In their decision to pursue a nexus assessment, the Parties to the Water Convention called for the assessment to provide a picture of the interdependencies across water, ecosystems, energy, food and other areas – such as climate change and biodiversity – in terms of uses, needs, economic and social benefits, potential synergies, conflicts and trade-offs, as well as to identify possible policy responses.

This implied the following objectives of the nexus assessment:

(a) To foster transboundary cooperation by identifying intersectoral synergies that could be further explored and utilized, and by determining policy measures and actions that could alleviate tensions or conflict related to the multiple uses of and needs for common resources;

(b) To assist countries in optimizing their use of resources, to increase efficiency and to ensure greater policy coherence and co-management;

(c) To build capacity to assess and address intersectoral impacts.

The Parties invited countries and joint bodies to express interest in the assessment, and in response to the proposals, the basins for the assessment were eventually confirmed.

The Meeting of the Parties established a Task Force on the Water-Food-Energy-Ecosystem Nexus to overview and guide the preparation of the nexus assessment. Chaired by Finland, the Task Force agreed on the main features of the assessment at its first meeting (Geneva, 8–9 April 2013). Notably, it was decided that a scoping-level assessment of the nexus, covering all confirmed basins, would be mostly qualitative and involve the identification of linkages and the major issues substantiated by appropriate indicators. The methodology was to be generic and applicable to diverse river basins and aquifers.

To develop the methodology, the UNECE secretariat, guided by the Task Force, adopted an evolutionary "learning-by-doing" process, and a draft methodology was developed, circulated for review, tested in practice in a pilot basin, and further reviewed. The methodological approach combines a participatory process of identifying jointly with the countries the main intersectoral issues and potential solutions together with a technical analysis of the physical resource base (water, energy, land and the environment) and the use of these resources, as well as their governance. Assessing the nexus in a transboundary setting is particularly challenging and complex, and applying a systematic approach to determine what is entailed in the nexus in practice is, for the time being, a rare undertaking requiring a fair amount of experimentation.

The methodology presented in Chapter 3 is the result of reviews undertaken at the second and third meetings of the Task Force (Geneva, 8–9 September 2014 and 28–29 April 2015). It takes into consideration the experiences from the three basins already assessed using the nexus approach: the Alazani/Ganykh River Basin (the pilot basin), shared by Azerbaijan and Georgia; the Sava River Basin, shared by Bosnia and Herzegovina, Croatia, Montenegro, Serbia and Slovenia; and the Syr Darya River Basin, shared by Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan.* The methodology is already applied in the assessment of the Isonzo/Soča River Basin, and it is expected that it will be applied in additional basins as part of the programme of work under the Convention for 2016–2018.

The nexus assessment is the result of the collective efforts of numerous contributors whose experience and insights were obtained from officials of the participating countries and the joint bodies for transboundary cooperation, including local and international experts, notably the Royal Institute of Technology (KTH, Stockholm), as well as many international partners such as the Food and Agriculture Organization of the United Nations (FAO), though there are too many to be acknowledged here.

The major findings of the basin-level assessments are presented in Chapter 4, followed by summary versions of the three assessments in Chapters 5–7. The full assessment reports are available electronically as reference documents, some of which are to be issued separately, resources permitting. The present report concludes with a number of lessons learned as well as recommendations for follow-up addressed to countries and organizations interested in embarking on a nexus assessment in a transboundary basin.

The present report begins with two chapters on the selected aspects of the water-food-energy-ecosystems nexus, namely, the application of a nexus approach in a transboundary basin, and governance and the nexus in a transboundary context.

* The Government of Uzbekistan decided not to associate itself with the Syr Darya assessment, while still observing the process. All reasonable efforts were made to provide Uzbekistan with the same information and opportunities to participate and the comments it provided were reflected in the assessment to the degree possible. Regional organizations and civil society from Uzbekistan contributed to the assessment.

CHAPTER 2

The application of a nexus approach in transboundary basins

This chapter provides an introduction to the nexus approach and how its application in transboundary basins may enhance water, energy, food and environmental security by increasing efficiency, reducing trade-offs, building synergies and improving governance across sectors and borders. The subsequent sections will discuss the nexus approach in relation to conventional integrated approaches and nexus-relevant governance at multiple levels with a focus on the transboundary level. This chapter will also describe how the use of the nexus approach supports the implementation of the Water Convention. A case is then made about the value of assessing the nexus in providing a strengthened basis from which to improve resource management through intersectoral coordination. The chapter concludes by looking beyond the assessments, namely the diverse solutions for addressing the nexus in practice, which the nexus assessments should indicate.

Pressures on shared resources and the effect of climate change

Water is used at variable intensities for energy production, not only is it used in hydropower plants it also serves as a coolant in other types of power plants. Conversely, energy is needed for extracting, transporting, distributing and treating water.[1] In the UNECE region, as well as globally, agriculture is the largest consumptive user of water. The predicted agricultural production increases required in the future to meet the growing population demands, coupled with the current push towards increasing the use of renewable energies (particularly hydropower and biofuels) will affect water and land resources. The possibilities for agriculture and food production are constrained by the limited suitability of land resources, which in some areas are threatened by land degradation. The development perspectives depend heavily on functioning ecosystems and the services they provide, specifically to these three sectors – water, energy and food. This is in addition to maintaining biodiversity and the many services derived from it, as well as climate change adaptation and mitigation. The pressures from population growth, urbanization, industrialization, economic development, climate variability and climate change add to the challenge of ensuring the availability of water in sufficient quantity and quality for its various uses. Accommodating the different sectors and promoting synergies between them supports the transition towards a green economy, which aims (among others) to improve efficiency in resource use and greater policy coherence.

At the national level, coordination between the water, energy and food sectors is fraught with difficulties, but the complexity increases substantially in transboundary basins where impacts can spread from one country to another. Across the UNECE region and globally there is great spatial variation, both in resource availability (or scarcity), as well as the means in place to develop and sustainably manage those resources.

Where competition between different resource domains is likely to increase, trade-offs need to be made deliberately, which requires management and containment through collaboration in a coordinated manner. Conflicting uses and trade-offs call for concerted efforts in order to accommodate the different sectoral needs and to promote synergies.[2]

The scarcity of future resources, ecosystem degradation and the risks associated with climate change are the most evident reasons to consider climate in the context of the nexus.

Lower run-offs, decreased rainfall, desertification, natural erosion and the increased frequency and intensity of extreme weather events of drought and floods are all examples of climate-related factors that will test the resilience of all sectors on their capability to respond and adapt to climatic changes. To "climate proof" the practices and operation of the various sectors means – from a nexus perspective – finding ways to use resources more efficiently, elaborating more coherent strategies for development across sectors, and assigning clear responsibilities and mandates to take action.

Several aspects of a nexus approach resonate well with efforts to adapt to a changing and variable climate: for example by improving water use efficiency that also reduces exposure to climate-induced physical water scarcity, or by shifting to more appropriate crops based on climatic conditions, land type and water availability.

In different ways and with different levels of commitment most countries are trying to reduce, stabilize or limit their contribution to global greenhouse gas emissions. Carbon markets are developing internationally to provide economic incentives for emissions reduction.[3] Efforts related to climate change mitigation may also impact on the nexus, thus requiring further coordination across sectors as mitigation actions may lead to counterintuitive negative impacts, while their expected benefits would need to be estimated by means of an accurate analysis of their impacts across sectors (Box 1).

BOX 1.
An example from Mauritius: intersectoral linkages and climate exerting pressure on water resources

In Mauritius a national biofuel policy that made sense as a best practice in terms of energy, land and water planning was shown to be strongly inconsistent. This was only discovered when the government and international analysts modelled these systems in an integrated manner, especially in response to climate change induced reductions in precipitation. It was shown that the change in rainfall patterns led to an increase in water withdrawals, which in turn led to a higher demand for energy to drive pumps to bring water from its source to the fields, and to power water desalination plants. A positive feedback loop meant that this led to increased demands on the cooling of thermal power plants and thus additional withdrawals of water. Since electricity demand is met with coal-fired power generation, the benefits of the biofuel policy with regard to greenhouse gas emissions were diminished by the increased emissions from the power sector.

Source: Mark Howells and others (2013). Integrated analysis of climate change, land-use, energy and water strategies, *Nature Climate Change*, vol. 3, pp. 621–626.

[1] United Nations World Water Assessment Programme, T*he United Nations World Water Development Report 2014, vol. 1. Water and Energy* (Paris, UNESCO, 2014). Available from: www.unesco.org/new/en/natural sciences/environment/water/wwap/wwdr/2014-water-and-energy/

[2] Ibid.

[3] The largest scheme currently is the European Union Emissions Trading System for trading greenhouse gas emission allowances, but there are various efforts more limited in scale. *Source: Emissions Trading Worldwide: International Carbon Action Partnership Status Report* (ICAP, Berlin, Germany, 2015).

The conventional integrated management approaches typically assume that the related sectors are static, or that their development is not fundamentally changed by the scenario drivers. This can result in important feedback effects, such as those described in Box 1, being ignored or overlooked. For example, climate change may change the intersectoral relations and the level of use of some of the resources.[4]

Towards greater policy coherence, and the obstacles on the way

Shortcomings in intersectoral coordination are a major challenge both on the national and transboundary levels for all countries whether they are developing countries, countries with economies in transition or developed countries.

The Issue Brief of the United Nations High-level Political Forum on Sustainable Development, *From silos to integrated policy making*[5] underlines the importance of taking into account interlinkages among the different areas of policy at the formulation stage for effective policy integration:

> ***"Achieving effective integration of the three dimensions of sustainable development goes beyond merely "aggregating" independently formulated policies across the different domains. It entails taking into account interlinkages among different areas of policy at the formulation stage. Integration implies that policymaking in any one area takes into account the effects of (and on) policies and outcomes in other sectors and areas. This will help ensure that policy is mutually coherent across the full range of dimensions, and that the effects of policy in one area do not contradict or undermine desired outcomes in others. This also enables to incorporate in sectoral policymaking cross-cutting dimensions that are crucial to achieving sustainable development, such as sustainable consumption and production."***

At the national level, policy fragmentation remains a challenge, as governments are often organized along sectoral lines, and effective intersectoral structures and coordination arrangements are commonly lacking. Furthermore, in many cases human, funding, infrastructure and other capacities may not be in place to facilitate efficient coordination and cooperation. With a shortage of capacity, the priority will often be to focus on core responsibilities such that cross-cutting efforts may suffer as a consequence. Better governance will require better coordination facilitated by improved relationships between different branches and levels of government. At the transboundary level, the sectoral priorities and policies of the riparian countries may be very different and additional coordination efforts would be beneficial for improving coherence and harmonizing approaches to the extent possible.

Integrated management approaches, such as integrated water resources management (IWRM), integrated energy planning and integrated land use assessment have been developed to study, plan and develop policy for resource management, while seeking to integrate different uses of the resource in question.

Examples of integrated management approaches demonstrate limitations in cases where resources are tightly interwoven.[6] Each approach examines future development scenarios for one sector, yet no consistent and concurrent scenarios for other sectors are normally made. Integrated management processes make intersectoral linkages explicit. However, they do not necessarily look beyond such linkages, which is why a non-water consuming activity in one country may impact water use in another. While this is clearly beyond sectoral management, it might not be apparent even in a (conventional) integrated management approach.

BOX 2.
The need to extend intersectoral planning: examples in agriculture

The interrelation of energy, irrigation and food security has become a serious issue in South Africa where electricity tariffs have increased by an average of 22 per cent between 2008 and 2013. That represents a cumulative increase of 330 per cent.[a] One of the areas that could be most affected by energy price increases is the agricultural sector due to its energy demand for irrigation. Some 25 per cent of South Africa's staple food is grown on irrigated land, and the area of irrigated land is planned to increase.[b] However, decreasing irrigation and a shift towards rain-fed agriculture could endanger national food security, especially during drought periods. South Africa was a net food exporter from 1985 to 2008 but, due to population growth and a declining increase in agricultural productivity in recent years, has become a net food importer.

As another example, the Punjab represents only 1.5 per cent of the territory of India, but its output of rice and wheat accounts for 50 per cent of the grain the Government purchases and distributes to feed more than 400 million Indians. A significant problem is that farmers are pumping ("mining") aquifers faster than they can be replenished (as electricity is subsidized, this is partially due to inadequate price signals) and, as water levels drop, increased pumping is sapping an already fragile and overtaxed electricity grid. Overall, irrigation accounts for about 15 to 20 per cent of India's total electricity use.[c]

[a] Eskom, Tariff History. Available from: www.eskom.co.za/CustomerCare/TariffsAndCharges/Pages/Tariff_History.aspx

[b] Tatjana von Bormann and Manisha Gulati (2014). The Food Energy Water Nexus: Understanding South Africa's most urgent sustainability challenge (Cape Town, World Wide Fund for Nature South Africa). Available from: www.wwf.org.za/

[c] IAEA, Seeking Sustainable Climate, Land, Energy and Water (CLEW) Strategies. In *Nuclear Technology Review 2009* (Vienna, International Atomic Energy Agency, 2009). Available from: www.iaea.org/publications/reports

Given the interconnectedness between economic sectors, a background paper for the Bonn Nexus Conference[7] concluded that a reduction of negative economic, social and environmental externalities can increase overall resource-use efficiency, provide additional benefits and secure human rights to water and food. Conventional policymaking and decision-making in silos therefore needs to give way to an approach that reduces trade-offs and builds synergies across sectors – a nexus approach. As an early proponent of the nexus concept, the World Economic Forum[8] viewed the security of water resources as dependent on the consideration of multiple sectors, namely, energy, trade, national security, cities, people, business, finance, climate and economic frameworks.

Since then, a wealth of integrated analytical initiatives have been launched to promote intersectoral or concurrent multisectoral approaches under a "nexus" umbrella, variably covering complex interlinkages between energy, water and food or agriculture, or at least some of these sectors. Looking at the interlinkages between water and energy for example, the *United Nations World Water Development Report 2014 Water and Energy*[9] lays out a wealth

[4] Consider a climate change scenario where rainfall drops and temperatures rise. An Integrated Land Use Assessment might consider the impacts of lower rainfall on crops and determine water requirements to be met with irrigation, assuming an outlook on water availability. It may go on to calculate the increased energy demand required to pump adequate water for crop irrigation requirements, assuming an outlook on irrigation and energy costs. However, it will not necessarily call on an Integrated Energy Planning Activity to assess – for the same climate change scenario – whether or not that extra energy can in fact be supplied, and if so, at what cost.

[5] United Nations Department of Economic and Social Affairs, Issue Brief, No. 5. 2014. This Issue Brief makes reference to the nexus assessments of the Alazani/Ganykh and the Sava basins carried out under the Water Convention.

[6] Mark Howells and others, Integrated analysis of climate change, land-use, energy and water strategies, *Nature Climate Change*, vol. 3, (June 2013), pp. 621–626.

[7] Holger Hoff, *Understanding the Nexus*, Background Paper for the Bonn 2011 Conference: The Water, Energy and Food Security Nexus (Stockholm, Stockholm Environment Institute, 2011). Available from: www.water-energy-food.org/en/news/view___255/understanding-the-nexus.html

[8] World Economic Forum Water Initiative, *Water Security: The Water-Food-Energy-Climate Nexus* (Washington, D. C., Island Press, 2011).

of evidence about the impact of the management of each of these resources on the other sectors, but it also points to various possible actions that can be taken in response. In a study[10] based on integrated modelling carried out at the International Atomic Energy Agency (IAEA),[11] the authors conclude that treating the three areas of the water-energy-food nexus holistically would lead to a more optimal allocation of resources, improved economic efficiency, lower environmental and health impacts, and improve economic development conditions. In short, an overall optimization of welfare.

So significant are the simulated impacts, taking into account climate change,[12] that governments and the global community are increasingly looking to improve nexus (or concurrent multisectoral) planning. At the same time, at the transboundary level, such efforts are still very limited.

Expanding integrated water resources management: water uses in the nexus

While the integration of water resources management at the river basin scale has been practiced for decades,[13] the paradigm has evolved and been enriched by, for example, the ecosystem management approach, having been influenced by ideas on governance, including stakeholder participation. The United Nations Conference on Environment and Development in 1992 recognized the challenges of managing water resources for a multiplicity of uses and threats that are set within the much broader context of changes in the economic, social and political landscapes. The World Summit on Sustainable Development in 2002 called for the development of integrated water resources management (IWRM) and water efficiency plans.[14]

While the IWRM concept already underlines the importance of integration between water resources policy, economic policy and sectoral policies,[15] a nexus approach extends further into integrated, intersectoral planning, lending itself to different scales and river basins – the basic unit for water management in IWRM – do not have the same preference or priority (see table 1 for a comparison of IWRM and nexus approaches).

The concept and scientific underpinnings of a "nexus" in the context of resource management is currently the subject of dynamic research. However, capturing the wealth of that research is beyond the scope of this chapter. Evidence of the practical value and influence of a nexus approach is still being gathered and remains to be evaluated.[16] Nevertheless, there is at least one characteristic of the nexus approach that makes cross-sectoral coordination interesting to promote. Owing to its broad perspective and the absence of a single-resource focus – such as water in the case of IWRM – the nexus approach allows for a more equitable dialogue across sectors.

TABLE 1
A comparison of IWRM and a nexus (intersectoral) approach

	IWRM	Nexus (Water-Food-Energy-Ecosystems)
Origin of a wider political recognition of the concept	Agenda 21, Rio de Janeiro, 1992	First Nexus Conference, Bonn, 2011
Trigger	Sectoral strategies and plans need more integration to meet key water supply goals.	Sectoral strategies and plans need more integration, and dynamic and dependent development scenarios to be considered.
Objective	Improve efficiency and sustainability in the use of water.[a]	Address externalities across sectors and achieve overall resource use efficiency.[b]
Entry point	Water use; water resources management.	Externalities between sectors; management of natural resources. The entry point can be different (e.g. water or energy) depending on the perspective of the policymaker and the priorities.[b] Seeks to engage different sectors in coordination on a more equal footing.
Main challenges	Securing appropriate water for people, food production, aquatic and terrestrial ecosystems. Dealing with variability of water in time and space with risks related to water flows, groundwater recharge and water quality. Creation of awareness and forging political will to act, promoting collaboration across sectors and boundaries.[c]	Defining actions, trade-offs and synergies in the provision of water, food and energy from resource to use, taking into account environmental needs. Harmonizing often diverging policy directions, targets and goals of different sectors.
Boundaries of a typical IWRM or nexus analysis	Basin or sub-basin.	Depending on the focus, could be local, national, basin level, regional or global.[a]
Sectors and resources	Water resources are at the centre and outlooks for different users and different needs are considered.	There is no universal methodology. Depending on the focus of the analysis, water, energy or land use can be at the centre. However, outlooks for other sectors are dynamic, responding to the same drivers as well as to feedbacks between sectors.
International dimension	Explicitly reflected where water bodies are shared, calling for transboundary cooperation.	Explicitly reflected where resources or linkages between sectors are shared. This would include, for example, transboundary water bodies but also regional power pools, etc. Also, commodity prices are influenced by global markets.

[a] GWP, *Integrated Water Resources Management*, Technical Advisory Committee (TAC) Background Papers No. 4 (Stockholm, Global Water Partnership, 2000).
[b] Holger Hoff, Understanding the Nexus, Background Paper for the Bonn 2011 Conference: The Water, Energy and Food Security Nexus (Stockholm, Stockholm Environment Institute, 2011).
[c] Morgan Bazilian and others. Considering the energy, water and food nexus: Towards an integrated modelling approach, *Energy Policy*, vol. 39, No. 12 (December 2011), pp. 7896–7906.

[9] United Nations World Water Assessment Programme, (Paris, UNESCO, 2014).
[10] Morgan Bazilian and others, Considering the energy, water and food nexus: Towards an integrated modelling approach, *Energy Policy*, vol. 39, No. 12, (2011), pp. 7896–7906.
[11] IAEA, *Seeking Sustainable Climate, Land, Energy and Water (CLEW) Strategies*.
[12] Mark Howells and others, Integrated analysis of climate change, land-use, energy and water strategies, *Nature Climate Change*, vol. 3, (June 2013), pp. 621–626.
[13] François Molle, River-basin planning and management: The social life of a concept, *Geoforum*, vol. 40, (May 2009), pp. 484–494.
[14] *Report of the World Summit on Sustainable Development, Johannesburg, South Africa, 26 August 4 September 2002*, chap. I, resolution 2, annex, para. 26.
[15] Global Water Partnership (GWP), *Integrated Water Resources Management* (2000).
[16] David Benson and others. Water Governance in a Comparative Perspective: From IWRM to a 'Nexus' Approach? *Water Alternatives*, vol. 8, (2015), pp. 756–773.

Governance and the nexus in a transboundary context

Institutional silos – discussed in section "Towards greater policy coherence, and the obstacles on the way" – typically characterize the management of natural resources relevant to the nexus as considered in this assessment. To address those silos and to develop the groundwork for resolving conflict among competing users, it is necessary to understand the needs, opportunities and challenges from a governance perspective.

In practice, what commonly stands in the way of more integrated planning and intersectoral coordination is the absence of agreements, as well as the limited mandates of institutions, or problems with their organizational structure, shortcomings in decision-making processes, and a weak enforcement capacity. Political differences, power asymmetries and competition for resources between sectors can also present obstacles.

These aspects, among others, are relevant when assessing the governance of natural resources as relevant to the nexus. Governance can be defined as an inclusive system of institutions and norms that establishes responsibility and accountability in decision-making, and builds trust and capacity to cooperate.

By now, thanks to developments in the water management community, as well as the efforts of the international and scientific communities — it has become quite clear what good governance of water entails, and as such related principles have been elaborated.[17] At the same time, because the nexus approach seeks the involvement of and interaction with different sectors on a more equal footing, notably agriculture and energy, what the approach implies in terms of governance is still very much a subject of discussion. Governance of each of the other resources in the nexus has its own particular features. Land governance, including the rules, processes and structures that determine ownership, access, and the use and control of land[18] is inextricably linked to the management of water, as well as other natural resources such as mineral resources, including fossil fuels.

Multiple levels of governance

Integration of the water and relevant policy sectors is essential to both the nexus and IWRM approaches. A fundamental prerequisite for this integration is the coordination between government agencies and ministries. Among the features commonly quoted as distinguishing the nexus approach from river basin focused IWRM is the spanning of multiple scales and the call for integrated policy solutions and multi-tiered institutions. Therefore, it is important to consider integration and coordination at multiple levels of governance.

At the transboundary level, in addition to the integration referred to above, it becomes crucial how riparian countries, which commonly have different sectoral and development priorities, can reconcile their different objectives and find common ground. Institutions for cooperation in the management of transboundary waters, which include river basin commissions or bilateral commissions, could provide a good starting point for improving the governance of the nexus. As many of those institutions have experience in bringing together different stakeholders across a basin, they lend themselves naturally to the implementation of nexus-based management approaches in shared basins.

Globally, river basin organizations have been established in more than 100 transboundary basins, including most major international basins. Joint institutions for transboundary cooperation around the world (with differing degrees of success) foster dialogue between different interests, provide support in harmonization and much more. How effectively institutions for transboundary cooperation can address or defuse intersectoral frictions depends on the institutional machinery in place, which includes, among others: well-defined and efficient decision-making mechanisms; mechanisms for data and information exchange, as well as for monitoring and compliance; procedures for notification of co-riparians on projects; mechanisms for ensuring a fair distribution of costs and benefits; and the quality of dispute-resolution mechanisms.[19]

Even though basin organizations and other institutions for transboundary cooperation can play a role in facilitating such intersectoral integration, it is clear that governance of the sectors in the nexus is not only about the river basin, but links strongly to both the national and regional levels.

National policies, as well as regional developments far beyond the basin, significantly influence how the intersectoral dynamics play out. Notably energy infrastructure, transmission and trade extend over large areas and therefore organizations like regional power pools and customs unions as well as trade agreements, are important players and factors in nexus governance. Even land management, which is easily perceived as rather local, is influenced by regional and global development, as demonstrated by the recent food and economic crises, which sparked a wave of foreign investments in land[20] whether for export food production, biofuel or speculation. Regional integration supports the harmonization of legislation and policies in various fields.

The extent to which a particular country has national mechanisms for intersectoral coordination is an important measure of the country's preparedness for integrated decision-making. Intersectoral coordination bodies may already be established in connection with other processes, such as sustainable development planning.

At the national level, the lack of a link between energy and water authorities for example, might mean that long-term energy sector development plans do not accurately assess water availability, resulting in unnecessary risks or inefficiencies. Established consultation processes across sectors about plans and policies help to take into account other sectors' concerns and to avoid false assumptions about them, hence reducing friction. The employment of sound, sufficiently broad technical and economic analyses to

[17] Peter Rogers and Alan W. Hall, *Effective Water Governance*, Technical Committee (TEC) Background Paper No. 7 (Stockholm, Global Water Partnership, (2013); and Organization for Economic Cooperation and Development (OECD), *OECD Principles on Water Governance* (brochure), 4 June 2015. Available from: www.oecd.org/env/watergovernanceprogramme.htm

[18] Paul Munro-Faure and David Palmer, An overview of the Voluntary Guidelines on the Governance of Tenure, *Land Tenure Journal*, vol. 1, (2012). Available from: www.fao.org/nr/tenure/land-tenure-journal/

[19] Susanne Schmeier. *Governing International Watercourses: River Basin Organizations and the sustainable governance of internationally shared rivers and lakes*, Earthscan Studies in Water Resource Management (New York, Routledge, 2013).

[20] Maria Cristina Rulli, Antonio Saviori and Paolo D'Odorico, Global land and water grabbing. In *Proceedings of the National Academy of Sciences of the United States of America*, vol. 110, No. 3. (January 2013), pp. 892–897.

inform decision-making is also of valuable support. Ministries whose mandate covers more than one sector of relevance to the nexus could in principle better co-optimize the use of those resources. However, there is also a risk that, for example, water policy is optimized to support a particular economic sector while other users might not be equally well accounted for.

The private sector has an important role to play in providing water services and access to energy. In the field of energy generation, transmission and distribution, the private sector commonly plays a major role and private law agreements may become an important factor in governing the operation of this sector. Both in countries where a market economy is predominant and in countries where State regulation is the main engine for change, legislation is important. Although its extent may differ, the role of the market and economic instruments in the allocation of resources is more prominent in market economies. In the energy sector overall, the influence of private enterprises is greater and market mechanisms are generally more prominent than in the field of water services. The governance structures, laws and policies should ensure that sustainability considerations and the wider public interest are taken into account.

Transboundary settings: use of the nexus approach to support implementation of the Water Convention

In transboundary settings, the impacts from development potentially propagate beyond State borders. Trade-offs and externalities may cause friction between the riparian countries and different interests. To avoid significant negative impacts from unilateral action, it is necessary to coordinate plans and management measures between the riparian countries.

Addressing the water-food-energy-ecosystems nexus at the transboundary level is about finding a balance between the various uses and the protection of the resource for sustainability, as well as managing the trade-offs and increasing synergies. Cooperation and dialogue is key if intersectoral conflicts are to be managed effectively at a transboundary scale. Guidance and frameworks for this are provided by instruments of international law, and existing structures for transboundary cooperation facilitate dialogue and coordination.

The key obligations under the Water Convention are the prevention, control and reduction of adverse transboundary impacts, as well as the equitable and reasonable use of shared water resources. To this end, the Convention requires its Parties to cooperate by entering into specific agreements and by establishing joint institutions (joint bodies). The definition of a "transboundary impact" in the sense of the Water Convention is broad,[21] with the Convention covering different water uses.

To achieve these objectives, effective interventions commonly need to be made outside the water sector, for example, where decisions regarding agricultural policy are made in order to reduce excessive water use or pollution. Water management authorities therefore need to work in close coordination with the different sectors of the economy. As such, the nexus approach can be seen as a subsequent (or even parallel) step to IWRM. The nexus approach strengthens transboundary cooperation by actively involving all sectors whose action can improve synergies.[22]

There are various benefits to be had from broadening transboundary cooperation beyond strictly water issues to opportunities with a clear intersectoral dimension. Including representatives from different sectors in a discussion on initiating or strengthening transboundary water cooperation will ensure that benefits,[23] which may otherwise go unidentified, are uncovered. Coordination, cooperation and exchange of information can help identify synergies for mutual benefit and reveal ways to address the trade-offs. Even if State borders pose limits to taking management measures, there is potentially more opportunity for benefits achievable only through joint action by looking at the basin as a whole and identifying the most suitable locations for developments.

Assessing the water-food-energy-ecosystems nexus is therefore important to enhance intersectoral coordination and transboundary cooperation, and more generally to inform policy development and management of natural resources. Hence the nexus approach is helpful to meet the obligations under the Water Convention as it moves towards a more equitable and reasonable use of water resources, limiting transboundary impacts and promoting cooperation.

The establishment of joint bodies, such as river, lake or aquifer commissions, is a main obligation under the Convention. Such joint bodies provide a framework for applying the nexus approach in practice as they can support coordination and efficiency of different water uses and accommodate them better in various ways. Joint institutions could also potentially promote coherence of adaptation efforts across borders and sectors.[24] They can do this, for example, by providing a framework for engaging with different economic sectors, agreeing on water allocation, seeking synergistic actions and coherence and reducing negative impacts from developments. Practical actions to this end include assessments, guidelines, decision-support systems, working arrangements and the involvement of experts.[25]

Box 3 presents some factors supporting intersectoral coordination identified among the Principles for effective joint bodies developed in the framework of the Water Convention.

[21] The Convention specifies that significant adverse effects on the environment include effects on human health and safety, flora, fauna, soil, air, water, climate, landscape and historical monuments or other physical structures, or the interaction among these factors. They also include effects on the cultural heritage or socioeconomic conditions resulting from alterations to those factors.

[22] Annukka Lipponen and Mark Howells, Promoting cross-border policy responses on the water and energy nexus, *Water Monographies*, vol. 2, (2014), Water and Energy, pp. 44–55 Available from: www.wcce.biz/index.php/issues/water/scow/188-water-monographies-ii-water-energy

[23] Policy Guidance Note on identifying, assessing and communicating the benefits of transboundary water cooperation (UNECE/MP.WAT/47), highlighting the importance of involving different sectors on transboundary water cooperation to identify new opportunities for mutually beneficial cooperation generating many significant benefits, ranging from accelerated economic growth to increased human well-being, to enhanced environmental sustainability and increased political stability.

[24] UNECE, *Water and Climate Change Adaptation in Transboundary Basins: Lessons Learned and Good Practices* (New York and Geneva, United Nations, 2015).

[25] UNECE, *River basin commissions and other institutions for transboundary water cooperation*.(New York and Geneva, United Nations Publications, 2009).

BOX 3.
Principles for effective joint bodies: factors supporting intersectoral coordination

As institutional arrangements for transboundary water cooperation are very diverse and their practices have been established under specific contexts, making general conclusions or recommendations regarding their set-up or operation is challenging. Despite this backdrop, certain principles of organization and activities that generally increase the efficiency of joint bodies and contribute towards reaching a mature level of cooperation between riparian States have been identified. Some of these "principles of effective joint bodies" directly touch upon the scope of cooperation and intersectoral coordination, notably the following:

(a) The broad competence of a joint body, which on the basis of IWRM, addresses in a complex way the entire spectrum of issues related to the sustainable development, management, use (including infrastructure) and protection of transboundary waters;

(b) A sufficiently broad and complete representation of national authorities in the joint body, involving participation beyond the water management authorities to include representatives from the ministries of the environment, fishery, agriculture, transport, health, energy, hydrometeorology authorities, economy and finance, as appropriate;

(c) A certain flexibility of the agreement establishing the joint body that enables cooperation to develop progressively in terms of scope, mandate and the riparian countries involved;

(d) A regular exchange of information and consultation mechanisms;

(e) A process that facilitates the assessment of impacts (transboundary and intersectoral) from developments, and the negotiation of an agreement on them among riparian countries;

(f) A framework for monitoring long-term impacts (e.g. infrastructure);

(g) Mechanisms for public participation and stakeholder involvement.

Source: Draft principles for effective joint bodies for transboundary water cooperation (UNECE/MP.WAT/2015/6). Available from: www.unece.org/env/water/mop7.html

Assessing the nexus as a basis to improve resource management through intersectoral coordination

Integrated assessments carried out across sectors can provide a strengthened knowledge base for the development of coherent policies that, in turn, support co-optimization and takes into account the different needs in developing transboundary basins.

Data gaps and asymmetric access to information are obstacles to more coherent governance. If information is missing or not available to all relevant departments or levels of government it can hamper productive dialogue and harmonized action. In transboundary basins, obtaining the necessary information basis and forming a holistic picture of the situation is more complicated where harmonized data would be needed from all the riparian parties with a significant share of and stake in the basin.

Furthermore, given that increased intersectoral coordination implies greater complexity, the need arises to communicate effectively with representatives of different sectoral interests, as well as with experts. Accessible, relevant and visual communication of information about intersectoral links helps to highlight the most relevant intersectoral linkages and therefore prompts action.

While all sectors are important in the context of transboundary basins, water provides a useful point of entry to a nexus analysis. The physical link it creates between countries calls for transboundary cooperation. It is increasingly obvious that different sectoral policies and development plans that significantly impact on the status of water resources are outside the domain and influence of water management, further underlining a need to cooperate closely with different economic sectors. An integrated analysis requires information about the different relevant sectors' projections, development plans and resource input requirements (for example, water requirements in terms of quantity, quality and timing).

The basin assessments carried out in this scoping level nexus assessment illustrate the possibilities based on the means and

available information, even though all of them were carried out with relatively limited time and resources. This type of overview of nexus issues and possible solutions can serve as a basis for follow-up studies focused on topical policy questions or some of the more perspective solutions emerging in a scoping level assessment. As discussed in the section "Emphasis on participation in this collaborative assessment", specifically defining the objectives with local, national and/or regional decision makers, as appropriate, can make the assessment a particularly valuable tool that responds to specific policy questions.

Countries participating in a nexus assessment specifically benefit in the following ways:

(a) An improved knowledge base on the linkages between sectors, to support decision-making at the national, basin and transboundary levels;

(b) The analysis and quantification of selected significant aspects of the nexus from the point of view of management challenges and the identification of possible knowledge gaps and their improvement;

(c) Joint identification of opportunities for benefits through, for example, intersectoral synergies and solutions to negative intersectoral or environmental impacts, addressing trade-offs and reconciling different resource uses;

(d) The promotion of dialogue between the different sectors from the riparian countries at the basin level, bringing together authorities, the private sector and civil society;

(e) The exchange of good practices across countries and between basins;

(f) Capacity-building, through workshops, exchanges, self-assessments and knowledge mobilization during the assessment process;

(g) The creation of or increase in awareness, and stimulation for further action on cross-sectoral issues.

By advancing knowledge, tool-kits, capacity-building and intersectoral transboundary dialogue, this nexus approach aims to help identify areas where coordinated planning, dialogue and governance holds new and effective paths to secure development that is sustainable. It seeks to offer insights into where integrated management might provide additional benefits and lay the foundations for future joint actions. The information generated can help in the coordination of policies and actions across sectors, institutions and countries.

Several other nexus approaches and specific analytical tools have been developed, ranging from those meant for simple mapping of interactions between sectors to those of complex systems analysis using models. In order to give some idea about the existing analytical possibilities, a cursory review of available tools is provided in section "Going a step further: tools and analysis methodologies available for quantifying the nexus", complemented by more details on selected tools in the form of an annex.

Beyond the assessment: solutions for addressing the nexus in practice

Nexus assessments should ideally point at practical actions that could be taken to reduce the trade-offs and negative impacts on other sectors or on the environment.

This section briefly presents a broad range of "solutions" to the nexus action types. It does not claim to be comprehensive but mostly attempts to show that existing tools and solutions can address the nexus challenges identified in an assessment exercise. Some of the solutions were actually proposed in the nexus assessments carried out under the Convention, others are broader. The overview of the basin assessments (chapter 4) discusses the solutions that specifically feature the three completed basin assessments.

Consistent with the categorization employed in the summary basin assessments, solutions to the nexus – discussed below in general terms – are divided as follows (with some examples);

(a) Institutions: intersectoral, multiple level governance, engaging resource users, appropriate assigning of responsibilities etc.

(b) Information: multisector information to support policy, assessing impacts across sectors, guidelines etc.

(c) Instruments: economic and policy instruments, Strategic Environment Assessment (SEA) etc.

(d) Infrastructure: built and natural infrastructure; investments in, operation and multiple use designs etc.

(e) International coordination and cooperation: sharing information and plans, trade, good practices etc.

These different categories of solutions are mutually supportive. They also partly overlap.

Institutions

The section on "Governance and the nexus in a transboundary basin" highlighted the challenges of resource management in sectoral silos and underlined the importance of multiple levels of governance managing water, energy and land resources, as well as ecosystem services. Efforts can be made at various levels of governance: regional, subregional, macroregional, transboundary, basin, national and subnational. At each level the opportunities and challenges for action, and the capacities of the relevant actors, including authorities, experts, stakeholders and others, influence how intersectoral issues can be addressed and what is applicable in terms of solutions.

At the transboundary level, coherence needs to be sought not only between national ministries and agencies but also between countries sharing the resource in question. Intersectoral issues at the national and subnational levels can be taken into account, and perhaps better accommodated, through a joint body for transboundary cooperation.

An appropriate representation of authorities and interests in a joint body stems from the actual resource uses in the basin (or aquifer) and their relative importance. It is crucial to involve the concerned stakeholders in decision-making on resource management. Basin councils or other forums for different interest groups are helpful in engaging stakeholders. Such institutions for transboundary cooperation can also have an important role to play in the engagement of civil society. While some basin organizations have effective strategies for communication and outreach for civil society, there is generally room for improvement in this area. It is important to guard against overrepresentation of particular interests and, to that end, it is helpful to review governance.

Depending on the reason why stakeholders are being engaged – to identify, notify, inform or consult – the most appropriate means of public participation should be selected. The UNECE Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters provides further guidance on this.

Insights into how nexus relevant governance can be supported are emerging from this nexus assessment, but also from other work of joint cooperation bodies in the framework of UNECE and the Water Convention.[26] From this experience, it seems that an intersectoral

[26] UNECE, *Strengthening Water Management and Transboundary Water Cooperation in Central Asia: the Role of UNECE Environmental Conventions* (UNECE/MP.WAT/35). Available from: www.unece.org/index.php?id=28204

or multisectoral approach can be promoted in practice in various ways, including for example by establishing institutions with responsibilities covering multiple sectors, and by setting up interministerial structures such as planning and coordination committees.

The methodology (chapter 3) describes the key features of organizations to be considered when assessing their contribution to facilitating intersectoral governance.

Information

The implementation of a nexus approach to manage the basins' resources requires better information to improve national level intersectoral coordination. Information related solutions can include, for example, improving monitoring, data management, and forecasting as well as extension programmes.

Balanced decision-making can be supported by jointly developed guidelines and strategic planning approaches that seek to define how, in practice, diverging interests can be weighed based on agreed relevant criteria.

One example is the *Guiding Principles on Sustainable Hydropower Development in the Danube Basin*,[27] which was elaborated by representatives from Danube countries and their relevant sectors, thus representing a shared understanding. The guidelines outline an approach towards increasing the hydropower potential while at the same time meeting the obligations of water management and environmental legislation.

International organizations also provide guidelines that have been developed in close coordination with their member States for putting into practice principles of good governance. One relevant example is the FAO *Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests* (box 4).

BOX 4.
Responsible practices in land tenure: guidelines of the Food and Agriculture Organization of the United Nations

How people, communities and others gain access to resources is defined and regulated by societies through formal or customary systems of tenure. Insecure tenure and resource use rights can have negative impacts on investment and productivity. Land users are less likely to invest in their land or use it in a way that is sustainable to ensure its long-term productive potential if they cannot reap the benefits.

Frequently, access to land has favoured certain individuals and groups of people at the expense of others. Women often have fewer and weaker rights to land. As such, secure tenure rights can make a difference in the social and political standing of more vulnerable groups. Often existing land rights are poorly implemented, not recognized, or require clarification to ensure local food security and social justice.

In this context, FAO and its partners embarked on the development of guidelines on responsible tenure governance, the *Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security*. These guidelines set out principles and internationally agreed standards for responsible practices, providing a framework for countries to develop their own strategies, policies, legislation, programmes and activities, and to judge what acceptable practices imply with regard to land tenure.

Source: Committee on World Food Security, *Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security* (FAO, Rome, 2012). Available from: www.fao.org/nr/tenure/voluntary-guidelines/en

Instruments

There are various regulatory instruments, in particular, minimum environmental flows but also transboundary environmental impact assessment (EIA) and strategic environmental assessment (SEA) (box 5), and land-use planning (box 6).

Another important category of instruments are the economic instruments (box 7) that include water and energy pricing, but also different environmental fees that can serve both to provide behaviour-altering incentives and to raise funds, including for the maintenance, repair and renewal of infrastructure.

Policy instruments that help address the nexus promote longer term planning and proactive policy development involving a broad consideration of impacts and alternatives, while also consulting different interests and relevant stakeholders. A valuable example is SEA (box 5). Even in the case of national instruments, it is customary to take into account international, transboundary and basin considerations.

BOX 5.
Strategic environmental assessment

Currently, SEAs of plans and programmes are initiated most commonly in the field of land use or urban planning, and also in regional development, energy, water management, waste management and transport. An SEA for a national energy strategy, for instance: helps define key aspects related to the effects of energy installations; evaluates a wide range of likely environment and health impacts; compares alternatives and pros and cons; determines adaptation and mitigation measures and actions; and helps move towards increased efficiency of resources. Similarly, SEA for a river basin management plan would help to assess in a comprehensive manner the optimal use of available resources that could boost the economy, while properly integrating water and parallel policy sectors, including energy, regional development and transport. Concerning energy in particular, a SEA can reveal the cumulative environmental effects of any planned hydropower plant early on in the process, while the environmental effects of the individual hydropower plants, as identified and addressed through the environmental impact assessment (EIA) procedure later at the project level, may not be significant.

A key feature of the SEA procedure is that it facilitates communication and consultations among stakeholders (central and subnational governmental agencies, the business sector or the public) in streamlining their policies – not only at the national level, but also at the international level in cases where transboundary impacts are expected – and by promoting transboundary cooperation.

SEA is therefore an important tool to support the intersectoral planning and consultation that the nexus approach also seeks to ensure.

In the pan-European region, EIA and SEA procedures are regulated by UNECE treaties[a] as well as EU and national legislation. At the international level, SEA is supported by international financing institutions, including the World Bank[b] and the Asian Development Bank,[c] and other expert and advisory bodies, such as the Netherlands Commission for Environmental Assessment.[d]

[a] That is, the Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention) and its Protocol on Strategic Environmental Assessment.

[b] World Bank, *Strategic Environmental Assessment* (2013). Available from: www.worldbank.org/en/topic/environment/brief/strategic-environmental-assessment and specifically on water: http://water.worldbank.org/topics/environmental-services/strategic-environmental-assessment

[c] Asian Development Bank, Strategic Environmental Assessment in the Greater Mekong Subregion (brochure) (Bangkok, ADB, 2015). Available from: www.adb.org/publications/strategic-environmental-assessment-gms

[d] See Netherlands Commission for Environmental Assessment, SEA. Available from: www.eia.nl/en/environmental-assessment/sea
There have been a number of recent capacity-building activities by the Netherlands Commission in Georgia (with UNECE), Uganda, Mali and Zanzibar.

[27] International Commission for the Protection of the Danube River. *Sustainable Hydropower Development in the Danube Basin: Guiding Principles* (Vienna, ICPDR, 2013). Available from: http://www.icpdr.org/main/activities-projects/hydropower

BOX 6.
Land management as part of the nexus toolbox

Spatial planning

The objectives of national spatial plans may be very broad and take into account various sectors, so they can provide a good entry point for intersectoral governance. For example, the objectives can include balanced regional development and improved social cohesion, promotion of regional competitiveness and accessibility, sustainable use of natural resources and protected areas, and protection and sustainable use of natural and cultural heritage and landscape.[a] Spatial plans may support the allocation of land for use where the necessary resource inputs are available and where the necessary infrastructure is in place, thereby enhancing synergies between economic activities. Spatial planning can also serve to site potentially hazardous activities in such a way that negative impacts are minimal.

Sustainable land management

The estimated costs of land degradation globally are as high as US$66 billion per year. The impacts of land degradation are often felt gradually and often in remote areas, rendering this severe problem largely invisible to decision makers at all levels; from national leaders deciding on development and land use policies to farmers and herders making day-to-day land management decisions. Causes for land degradation are numerous and include declines in soil fertility, the development of acidity, salinization, alkalization, deterioration of soil structure, accelerated wind and water erosion, and loss of organic matter and biodiversity. Efforts to restore productivity of a degraded land must be coupled with efforts to recognize the productive capacity of land resources, as well as the interlinkages with other resource systems.

Solutions on how to address land degradation are well understood and can be fairly low-cost. Sustainable land management (SLM) aims to maintain the long-term productivity of the ecosystem functions (land, water, biodiversity) while simultaneously increasing the productivity (quality, quantity and diversity) of goods and services, and particularly safe and healthy food. SLM encompasses other established approaches such as the sustainable intensification of existing farmlands through efficient management of nutrients (combining organic and inorganic sources of fertilizers), integrated management of land and water resources ("blue water" and "green water") and diversification of mixed farming systems. Practices include agroforestry, conservation agriculture, rainwater harvesting, and integrated soil fertility management. The application of different measures and approaches to sustainable land management is strongly context dependent.

Source: FAO

[a] These objectives, for example, are from the 2010 Spatial Plan of Serbia for the period 2010–2020 (see UNECE, *Environmental Performance Reviews: Serbia – Third Review*, Environmental Performance Reviews Series No. 42 (New York and Geneva, United Nations, 2015).

BOX 7.
Economic instruments as part of the nexus toolbox

From a nexus perspective, economic instruments can provide incentives to use resources more efficiently and to promote investment in resource-efficient options. Appropriate pricing of natural resources can signal scarcity and the right timing for investment. For instance, where water prices are set efficiently, the optimal timing for investment is signalled by market prices: a fall in water availability pushes water prices up, inducing investments in water use efficiency or in developing new sources of water, thereby balancing the supply and demand for water. The same dynamics hold for energy or food. In addition, economic instruments in use to manage the water-food-energy-ecosystems nexus make pollution costly, save investment costs, promote flexibility, allocate water and water-related risks, and stimulate the diffusion of innovation.

Subsidies that run counter to a coherent approach of the nexus (e.g. fossil fuel subsidies or budget support in agriculture) need to be assessed and corrected. The potential benefits are manifold: increased efficiency of economies, alleviation of distortive effects on competition, and additional public funds available for more valuable uses. While the potential benefits of economic instruments to manage the water-food-energy-ecosystems nexus are substantial, the design and implementation of these instruments are difficult. Economic instruments can generate distributional or equity issues, trigger rent-seeking behaviour, and prompt political resistance. In addition, they require specific prerequisites, as well as the anticipation and management of interactions with other instruments in the policy mix. Thus, reform processes need to be well planned and communicated clearly, and must consider distributional impacts. Accompanying measures are needed to ease the development and implementation of economic instruments for the nexus. Compensation schemes, either monetary or in another form (e.g. funding more efficient technology), may have a role to play as catalysts for a transitory period.

Sources: OECD (forthcoming), *The Benefits of Transboundary Cooperation in Georgia and Azerbaijan - Kura River Basin* (Paris, OECD Publishing, 2014); *New Perspectives on the Water-Energy-Food Nexus,* Background Note to the Global Forum on the Environment focused on the water-food-energy nexus, 27–28 November 2014, OECD Headquarters, Paris; OECD, *Water Security for Better Lives* (Paris, OECD Publishing, 2013); OECD, *A Framework for Financing Water Resources Management* (Paris, OECD Publishing, 2012).

Preparation of national climate change adaptation plans and adaptation related exchange of information at the transboundary level can contribute towards intersectoral coordination (Box 8).

BOX 8.
Adaptation plans on climate change and intersectoral coordination

The United Nations Framework Convention on Climate Change (UNFCCC) has emphasized the importance of involving various sectors in both the preparation and implementation of National Adaptation Plans (NAPs). The NAP technical guidelines emphasize that "relevant sectors and other management units can respond and report to national governments on their plans and programmes to address adaptation to climate change, including efforts to cooperate across sectors and within specific areas such as regions and cities".[a]

[a] United Nations Framework Convention on Climate Change (2012). *National Adaptation Plans: Technical guidelines for the national adaptation plan process*, Least Developed Countries Expert Group. Available from: www.unfccc.int/adaptation/workstreams/national_adaptation_programmes_of_action/items/7279.php

Infrastructure

The way infrastructure in the fields of water (dams, treatment plants, conveyance pipes etc.) and energy (fuel extraction, power plants, buildings etc.) are designed and operated has a huge influence on resource intensity. Smart, resource efficient technologies that are well adapted to the location and needs can significantly reduce the use of inputs as well as emissions.

Promoting the multiple and flexible use of infrastructure, in particular dams, irrigation and drainage systems, is also useful. In addition, hydropower generation may, for example, serve flow regulation for navigation and flood protection. By adopting appropriate designs, fish passes for example may limit the impacts of structures on migratory fish, or the installation of smaller, run-of-river type hydropower plants may have lesser negative impacts on other users such as the environment.

Investments in upgrading infrastructure, but also coordinating investments across sectors such as in hydropower and intermittent renewable energy sources that need to be integrated with pumped storage, can be very beneficial. Sustainable and integrated planning can help make future infrastructure less maintenance intensive, less expensive and more efficient,[28] but also more widely accepted. With appropriate applied procedures in place, environmental impacts can be reduced, or benefits for multiple sectors can be secured from planned infrastructure investments. Some investors, like development banks, set requirements such as an EIA as a condition for financing projects.

Natural infrastructure assets should be protected and considered as potential alternatives to built infrastructure (box 9).

Policies also drive technological development and innovation, and technology can have either beneficial or counterproductive effects on intersectoral dynamics.

BOX 9.
Green infrastructure as part of the nexus toolbox

Nature can substitute, safeguard or complement built infrastructure projects in ways that are proven to be effective and cost competitive with business as usual. Natural infrastructure, such as forests, floodplains and riparian areas, can provide many of the same services as built infrastructure, including the ability to filter water, minimize sedimentation, and reduce the impact of floods along with additional benefits, such as the ability to sequester carbon and even provide food. Transboundary basins and aquifers add another level of complexity in the effective use of natural infrastructure that can benefit sectors and countries.

Natural infrastructure is still most commonly used as a reactive safeguard at a small scale. There is a need to determine what it takes to move from small, isolated natural infrastructure initiatives towards a coherent global movement where natural infrastructure is considered a core strategy to manage water, energy, and food security risks at national and transboundary levels. This can be partially achieved by demonstrating the business case for investment.

Source: IWA and IUCN, *Nexus Dialogue on Water Infrastructure Solutions*, reference library of selected tools and case studies on natural and built water infrastructure in the nexus (International Water Association and International Union for Conservation of Nature, 2015). Available from: www.waternexussolutions.org

International coordination and cooperation

While national actions allow a lot to be done to reduce negative intersectoral effects, international cooperation and coordination at both basin and regional levels add to the possibilities of "managing the nexus".

International trade, relations and regulation can heavily affect the patterns of the above water uses. Examples of drivers include regional food and energy markets. As important quantities of electricity and fossil fuels could be traded across borders, energy policies have the potential to mitigate or aggravate friction related to water use. Input intensive production may increase pressure on the shared water resources with negative transboundary effects, but importing from another country with a higher resource endowment might offer a concrete alternative. Therefore, trade facilitation or Free Trade Agreements that deepen and expand the basis for trade of energy or agricultural products would allow countries to make the best of their domestic assets.

Examples of integration processes and policy coherence from the EU are especially relevant (Box 10) given the wealth of the EU experience, as well as good availability of information, in regional integration and policy development covering various sectors. Over the past 15 years, in particular, a lot of effort has been put into assessing and improving the coherence of sectoral policies in the EU.[29]

[28] The linkages between the water and energy sectors, as well as governance and private sector participation, are discussed in the World Water Development Report 2014, vol. 1, *Water and Energy*.

[29] Andrew Jordan, Adriaan Schout and Martin Unfried, Policy coordination, In *Environmental Policy in the EU: Actors, Institutions and Processes*, third ed. (London and New York, Routledge, 2013).

BOX 10.
Regional integration processes and policy coherence[a]

The EU has a comprehensive legal framework that is the result of lengthy development and is applied by countries in very different conditions. It also influences legislation and policy well beyond the EU. Approximation to the EU *acquis communautaire* leads to the gradual harmonization of legislation and policy frameworks, facilitating also transboundary cooperation. Both the improvements made to achieve a greater coherence between sectoral policies and the remaining challenges are instructive.

Achieving greater policy coherence within European water policy was a key reason for introducing the EU Water Framework Directive (WFD) in 2000.[b] It complemented and completed other EU water-related directives and regulations and helped to settle some earlier inconsistencies. It also introduced a strong emphasis on public participation in planning water resources management. A large number of other environmental policies are linked to the EU water policy framework, of which the Habitats Directive[c] from among the protected areas directives and the Integrated Pollution Prevention and Control Directive[d] can be mentioned as examples. A survey in support of "The Fitness Check of EU Freshwater Policy"[e] highlighted a need to improve further the integration of water policy with relevant environmental directives. Harmonization of reporting schedules for different water directives has been proposed as one means to that end.[f] Building on this "Fitness Check" and on an impact assessment of "A Blueprint to Safeguard Europe's Water Resources",[g] a set of policy options for action at EU level were identified and assessed.[h]

Regarding agricultural policy, the Common Agricultural Policy (CAP) of the EU was found to have been a key driver of farming practices that in many cases enhanced water pollution and scarcity. Policy changes introduced through the reform of the CAP in the 2000s have increased the importance of environmental protection in the policy, underlining the value of this kind of review, as agriculture is commonly a major water user and impacts on water quality.[i] However, more remains to be done to improve the coherence of the CAP with water policy.

Harmonizing energy policy (with respect to some renewable energy sources and targets for biofuel production) with water policy objectives has been identified by the EU as an important area for future policy development. Unfortunately, the goals of green energy policy had not being fully aligned with the environment-related objectives of the WFD.

The above demonstrates that improving policy coherence is a long-term effort. The EU neighbourhood countries that approximate their legislation and policy to that of the EU benefit from the results of extensive experience of integration and increasing policy coherence across a region (and the same could be said about UNECE instruments). On the other hand, each country has to adapt and apply regional instruments in their particular setting.

The approximation processes to the EU *acquis communautaire* result in potentially valuable reviews of legislation and, on occasion, in the establishment of national organizations with an intersectoral or interministerial mandate that can improve coordination and support checks for coherence.

[a] This section builds on the findings of the publication by the Institute for European Environmental Policy and Deloitte Consulting, *Support to Fitness Check Water Policy*, which served as the report to the European Commission General Directorate for Environment on the project, "Request for services in the context of the framework contract on evaluation and evaluation-related services ABAC N°101934" (14 June 2011). Available from: www.yumpu.com/en/document/view/25782586/water-policy-fitness-check-institute-for-european-environmental-

[b] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000, establishing a framework for Community action in the field of water policy.

[c] Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and wild fauna and flora.

[d] Directive 2008/1/EC of the European Parliament and of the Council of 15 January 2008, concerning integrated pollution prevention and control. This has since been replaced by Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control).

[e] European Commission, Staff Working Document, SWD (2012) 393 final (Brussels, 15 November 2012). Available from: http://ec.europa.eu/environment/water/blueprint/fitness_en.htm

[f] For details of the survey and the findings, see Institute for European Environmental Policy and Deloitte Consulting, *Support to Fitness Check Water Policy.*

[g] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee, and the Committee of the Regions, COM (2012) 673 final (Brussels, 14 November 2012).

[h] See EU, *Impact Assessment and support studies for the Blueprint to safeguard Europe's water resources*, last updated 22 April 2015. Available from: http://ec.europa.eu/environment/water/blueprint/ia_en.htm

[i] European Environment Agency (EEA). *A Green CAP? Reform options from an environmental angle*, EEA Green CAP project, Interim report first phase (Management Board meeting, 23 June 2011). Available from: www.eea.europa.eu/themes/agriculture/greening-agricultural-policy/ (see 'Greening the CAP' – first phase report).

Regional and global standardization can also promote coherence by taking into account resource efficiency and aspects of environmental protection, notably in the following areas: methodologies (ISO standards), legislation (EU influence) and policies (UNECE and EU).

CHAPTER 3
Nexus assessment methodology and its development process

Introduction: the nature, scope and potential value of the nexus assessment

The nexus assessments undertaken under the Water Convention are intended to provide a picture of the interdependencies across water, ecosystems, energy, food and other areas such as climate change and biodiversity in terms of uses, needs, economic and social benefits, potential synergies, conflicts and trade-offs, and also to identify possible policy responses.

The approach seeks to combine a sound analysis of interlinkages (impacts, trade-offs, benefits) with a joint identification of actions that can improve the coherence of policies, intersectoral coordination and transboundary cooperation. An integral part of the process is an intersectoral, transboundary dialogue.

The approach used considers special characteristics associated with transboundary basins, looking at the physical link that the water body forms between riparian countries, and takes into consideration whether the basin area plays a special role within the country, as is often the case. The role of the basin area is part of a local-to-national dynamic, as well as transboundary dynamic, that adds to the intersectoral linkages. The general assessment framework developed is applicable to assess diverse basins, while the methodology allows for flexibility to adjust to the characteristics of each basin. In addition to the transboundary focus, a specificity of the UNECE nexus approach is the explicit recognition of ecosystems. From a substantive and analytical point of view, the approach builds on the Climate, Land-, Energy-, Water-use (CLEW) framework.[30]

More specifically, the methodology provides for the identification of positive and negative linkages, benefits and trade-offs among sectors at the national and transboundary levels, while assessing their relative importance and exploring their development in the future, taking into account climatic and socioeconomic changes. The methodology also sets a basis for the quantification of a number of these features such that – depending on the setting, the nexus issue and data availability – appropriate quantification tools for specific analyses can be identified.[31]

Even more important than identification and analysis, the process involves an intersectoral dialogue in a transboundary context that is informed by a joint assessment. The methodology's application has demonstrated that it facilitates such a dialogue. The representatives of the countries of the assessed basins have appreciated the opportunity for intersectoral discussions, which are not common practice even at the national level.

The methodology has an important participatory dimension employing an intersectoral nexus assessment workshop involving the sectors concerned, as well as a representative set of key stakeholders and interest groups. The joint identification of issues, mapping and capacity-building, together with officials and experts from the countries sharing the basins, are among the elements assessed. Moreover, reviews of the findings by the national administrations, other stakeholders and consultation meetings are among the key elements of the approach. The governance assessment component of the assessment methodology informs and helps to verify who (among the organizations and actors) should ideally be involved in the process. It is recognized that consulting various stakeholders and incorporating their views into a nexus assessment from the outset is instrumental to its success, thus ensuring its responsiveness to specific needs and circumstances.

In the end, the nexus methodology leads to the identification of concrete actions to reduce tensions between sectors and countries. The best way to demonstrate the utility of the UNECE nexus approach is to point to the potential solutions that have surfaced during the basin assessment studies. These solutions have been jointly discovered by national stakeholders and international partners involved in the development of the three basin assessments. Further details on these nexus solutions and on the findings from the three initial basin assessments can be found in chapter 4. Each of these solutions necessarily traverses sectors, sectoral planning and boundaries, yet has strong economic and other development drivers.

Upon application, the approach has evolved to a certain degree and gradually the methodology has become more refined. Despite the relevant information produced by its application and the merits in fostering a dialogue, some limitations should be noted from the outset with the resulting assessment largely remaining at the level of an overview. Furthermore, the methodology does not include the cost and benefit analysis of different policy actions nor does it provide for a risk analysis. Finally, how comprehensively the different components of the nexus can be covered is influenced by the extent of participation of the countries and sectors concerned.

With the data availability also playing a role, there are differences in the scope and level of detail in the assessments carried out. Notably, in the case of the Alazani/Ganykh River Basin, the limited data available constrained how much could be concluded. The assessment of the Sava River Basin, thanks to a KTH modelling

[30] Mark Howells and others (2013). Integrated analysis of climate change, land-use, energy and water strategies, *Nature Climate Change*, vol. 3, pp. 621–626.

[31] Some possible tools for intersectoral analysis are described in section 'Going a step further: tools and analysis methodologies available for quantifying the nexus' (at the end of chapter 3). At the scoping level, for assessments carried out in the framework of the Convention's programme of work for 2013–2015, the quantifications have been relatively limited.

project but also partly to a parallel nexus project of the European Commission Joint Research Centre, allows for significantly more detail and quantified findings to be presented.

What can be achieved in a nexus assessment depends on various factors: the context, the issues, the actors involved, the constructiveness of the dialogue, and the availability of information and political will.

Basic principles of the nexus assessment

To achieve the objectives of the nexus assessment, the following principles should be applied in the approach to this exercise:

(a) Participatory process: The process should be participatory, working with the national administrations of the riparian countries in line with the collaborative spirit of the Water Convention. The views of all the relevant stakeholders and sectors should be taken into account to ensure ownership. By using a nexus approach it is possible to engage a variety of sectors to discuss intersectoral issues without being limited to a specific sector or aspect (e.g. climate or water management), making it possible to stimulate dialogue on development priorities, existing constraints and the shared benefits of coordinated actions;

(b) Knowledge mobilization: The available expertise in the basins assessed should be used to the maximum degree possible. Particularly relevant for the nexus assessment of a basin is the local knowledge and experience of the issues and circumstances, including studies, databases and models of the hydrology, energy system, land use and ecosystems, as well as experiences from projects and activities aimed at improving resource efficiency and intersectoral and transboundary cooperation;

(c) Sound scientific analysis: A sound scientific analysis should inform the process, while drawing upon past experiences to improve the quality of the assessment outcome. The analysis should be appropriately scaled according to the available financial and human resources. Even with significant constraints, data requirements can at least be identified, as well as possible sources and approaches;

(d) Capacity-building: The assessment process should help all parties understand the intersectoral linkages better, as well as to gain experience in the sustainable management of natural resources by sharing examples, promoting constructive discussion across States and sectors, and providing the tools required to address nexus issues at the basin level;

(e) Collective effort: The outcome of the nexus assessment should reflect the broad range of views and expertise involved throughout the process;

(f) Benefits and opportunities: Focusing a large part of the dialogue and assessment on uncovering potential for improvement and the possible benefits from cooperative and coordinated solutions is also a guiding principle of the methodological approach, as it allows for a more constructive, solution-oriented participation and outcome that may attract or mobilize wider support.

Emphasis on participation in this collaborative assessment

A key element of this nexus assessment approach is the identification of issues, mapping and capacity-building made jointly with officials and experts from the countries sharing the basins. This process helps develop dialogue from one sector to another, across borders and between the local and national levels.

In particular, according to a recent study[32] consulting various stakeholders and incorporating their views into a nexus assessment from the outset is instrumental to its success, which in turn ensures its responsiveness to specific needs and circumstances. Effective stakeholder engagement in a nexus approach should involve consultations with:

(a) Local, national and regional decision makers so as to present relevant policy questions early on in the process;

(b) Rural and urban planning authorities and resource managers who can provide information on future development plans and any conflicting development viewpoints;

(c) Practitioners[33] who can quantify and prioritize various nexus issues;

(d) Resource analysts and modellers who can discuss and align modelling scenarios, assumptions and input data.

During the consultations it is particularly important to identify the perceptions of actors and other stakeholders regarding intersectoral linkages, benefits and trade-offs and their expected future development, as well as resource security concerns. The consultations can ensure that local, national and regional strategies and goals are adequately considered within the assessment process and that the assessments are targeted to the constraints in each particular context. This ultimately enables the key stakeholders to affirm and refine potential strategies and actions that address the intersectoral issues identified, and to help pinpoint areas in which the respective sectors may enter into competition.

It is recognized that undertaking an intersectoral assessment where the objectives are specifically defined with local, national and regional decision makers can create a valuable tool to answer specific questions, as well as ensure its findings are useful to inform on future policies. However, the nexus assessment in the framework of the Convention is scoping in nature; it is meant to provide an overview of the intersectoral links in order to identify the related opportunities for acquiring benefits, for example, in terms of reduced (or internalized) negative externalities, improved resource efficiency and related economic benefits, as well as greater sustainability.

Phases of developing the assessments 2013–2015

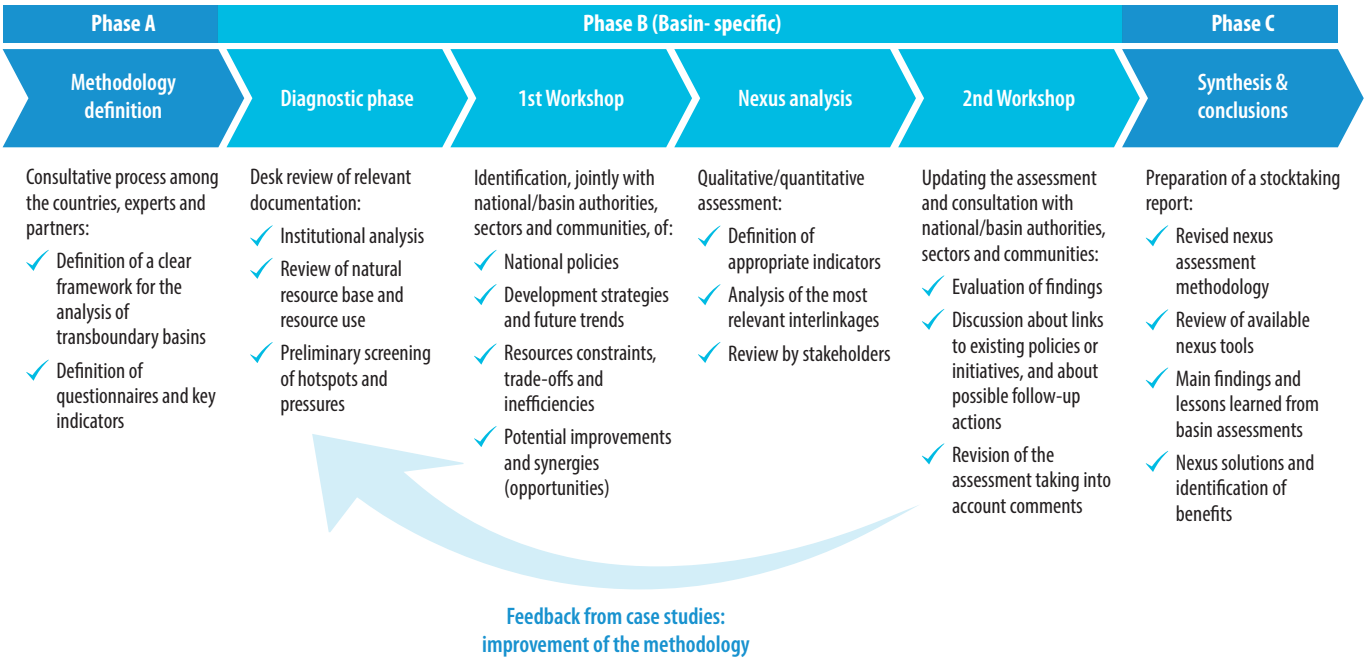
The nexus assessment involves three phases. Phase A is the development of a broad methodology. Phase B focuses on applying the methodology to analyse a specified set of transboundary river basins, the application of which is composed of four parts: (a) first, a diagnosis of the basin; (b) next, a workshop where key issues and possible synergetic solutions are jointly identified; (c) then, the drafting of a final report that synthesizes the information, backs it up with descriptions and analysis, and provides illustrative quantifications to justify the conclusions (including possible coordinated actions); and (d) finally, a second, follow-up workshop to explore opportunities for discussing the findings with country officials (and other key stakeholders), with the possibilities of taking responsive action such as including outcomes from the assessment into actual policies and activities. The third work phase, Phase C, results in a consolidated summary of the assessment findings.

The sequence of the phases is presented graphically in figure 1.

[32] A report from the United Nations Development Programme (UNDP)/Global Environment Facility (GEF) project: Reducing Transboundary Degradation in the Kura Ara(k)s River Basin. *Pilot Study: Applying the Nexus Approach in the Transboundary Alazani/Ganikh River*. Available from: www.kura-aras.org/Digital_Library.html (as Nexus Summary Report).

[33] The term refers to individuals who work in the relevant sectors in resource management or environmental protection.

FIGURE 1
Phases of work



Phase A

The definition of the general methodology for the nexus assessment, Phase A creates a basic structure that includes the development of a consistent terminology, an organizational framework, indicators, and preliminary areas of investigation. These are then applied in Phase B to different transboundary basins and the results synthesized in Phase C.

From the beginning of the assessment process under the Water Convention, the application of this methodology to the basins (Phase B) was intended to test the appropriateness of the methodology (the pilot) with the lessons learned from the different basin assessments serving to further improve it. This increases the value and usefulness for future basin assessments. The basins, to which this methodology can be used for analysis, may be very different. Hence, the objective was to come up with a simple structure that could be replicated in each basin, while at the same time allowing a high degree of flexibility that responds to different circumstances and sets of intersectoral issues.

Phase B

Phase B comprises six steps (see table 2) with several objectives, including:

(a) To identify nexus issues. Selected examples that illustrate the need for cooperation may be quantified;

(b) To identify potential nexus solutions. Selected examples of benefits may also be quantified;

(c) To build capacity in the process and support a dialogue between representatives of key sectors from all the riparian countries;

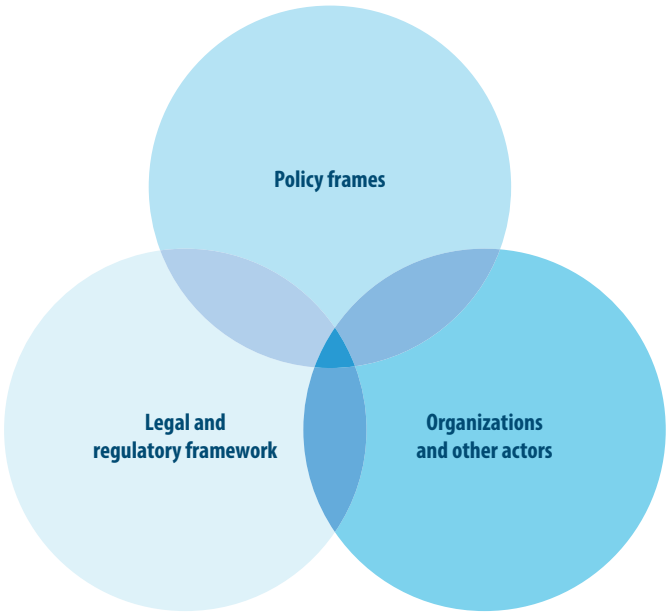
(d) To pinpoint key data, indicators, processes and aspects of management and coordination that may support joint or coordinated actions;

(e) To discuss opportunities to include findings from the assessment in current policy developments, management measures or follow-up projects.

The assessment of the basin evolves on two main tracks: the (technical) analysis of natural resources and the analysis of governance.[34] These are parallel and complementary efforts that inform each other. The first track of analysis looks at the geography, climate, resource uses and flows, as well as the physical linkages between sectors. The second track aims at capturing the relevant features of the governance context, namely the legal and regulatory framework (1), organizations and actors (2) in the water, energy and agriculture sectors, as well as environmental protection at the local, national, basin, transboundary and regional levels, and the main policies (3) with a focus on policy coherence, as well as gaps, overlaps and complementarities of responsibilities (figure 2).

It should be noted that this process draws from several information sources and key sets of indicators. These are described in annex I.

FIGURE 2
Aspects of governance analysed



[34] The governance analysis covers the institutional framework, legal basis and the main policies.

Phase C

Phase C involves drawing conclusions and lessons from each of the basin assessments and developing recommendations regarding intersectoral coordination in transboundary basins. The conclusions highlight the value of an integrated, cross-sectoral approach in resource management to improve water, food, energy and environmental security, and to support transboundary cooperation.

Nexus assessment of a transboundary basin

Assessment process

The nexus assessment of a transboundary basin involves analysts, authorities and various stakeholders. Their role in the assessment process is illustrated in figure 3.

A six-step process is proposed for the analysts to organize the work and ensure focused and timely communication with stakeholders. This includes various kinds of input and validation, information-gathering, joint identification of issues, and potential solutions and engagement of key officials and experts.

The six steps, revised and improved with the feedback from the three case studies, are described in the following paragraphs and, for each, some improvements are suggested and reviewed. In each step the participation of the key stakeholders is critical.

Steps 1 to 3 support the desk study, which helps to initiate the stakeholder consultations and participation processes by raising awareness and developing a preliminary understanding of the main issues and challenges in the basins, as well as providing an initial idea of the potential opportunities for cross-sectoral cooperation. Building on step 3, steps 4 to 6 constitute the core activities of the participatory workshop and the analysis of its outcomes.

FIGURE 3
Information exchange in the nexus assessment of a basin

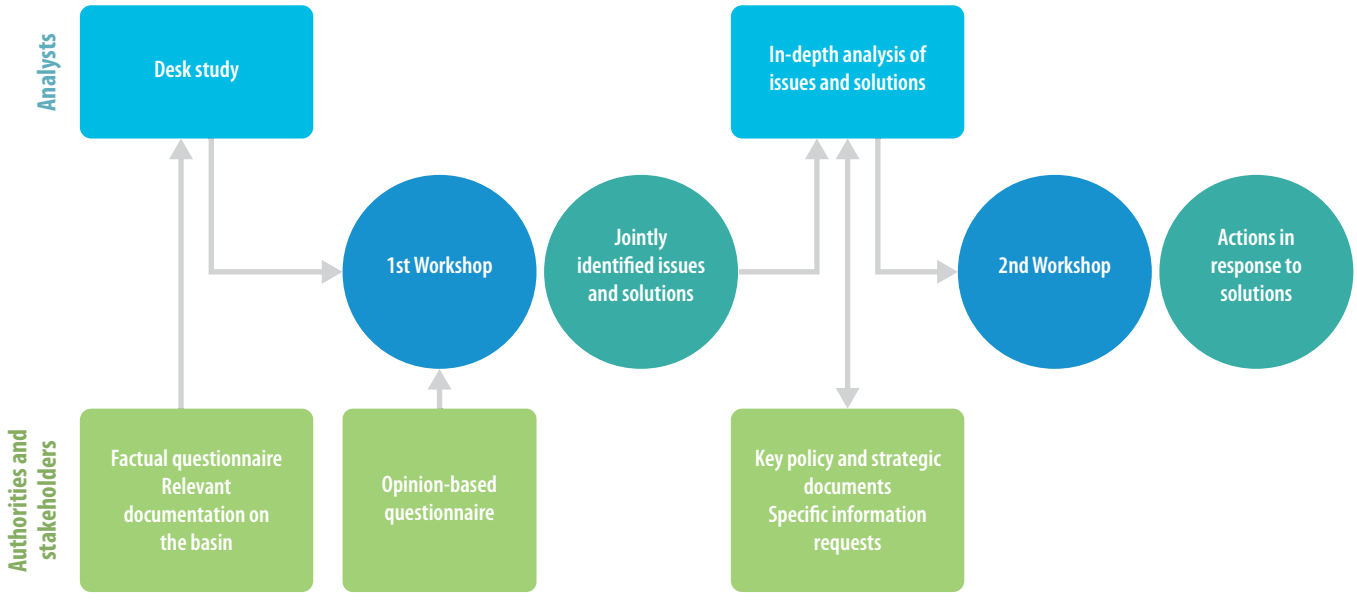


TABLE 2
Steps of the nexus assessment of a basin

Step	Actors	Location	Sectors
1. Identification of basin conditions and the socioeconomic context	Analysts	Desk study	General. Information normally used to underpin sectoral planning. Key elements include general socioeconomic goals and targets.
2. Identification of key sectors and stakeholders to be included in the assessment	Analysts and authorities	Desk study	General. Requires expert judgment and understanding of local context and governance.
3. Analysis of the key sectors	Analysts and authorities	Desk study/ first workshop	Individual sector experts and plans. Key elements include identification of the resource base and uses, as well as institutional mapping.
4. Identification of intersectoral issues	Stakeholders	First workshop	Sectoral group discussion on interlinkages (input needs, impacts and trade-offs), and discussion on sectoral plans.
5. Nexus dialogue and future developments	Stakeholders	First workshop	Agree on a prioritization of main interlinkages, including how they are expected to change, according to jointly identified development trends, noting key uncertainties and most important drivers.
6. Identification of opportunities for improvement (across the sectors and countries)	Stakeholders and analysts	Desk study, first and second workshops	Identification of solutions with multiple impacts between sectors, scales and boundaries. Such solutions could eventually be integrated into policies and programmes in the countries/basins.

As the nexus assessment seeks to examine intersectoral issues and uncover potential opportunities for cooperation in the specific context of the basin considered, a "zoom-in" approach is suggested to first investigate the broad socioeconomic situation and the resource base of the basin, and then gradually to focus on sectoral analysis and intersectoral implications.

The primary objective of the analysis will be to describe the different options for reducing negative impacts and to take advantage of complementarities and opportunities for cooperating and sharing benefits. These are normally basin specific, which means that the analysts need to be ready to consider a variety of interlinkages. In identifying these intersectoral and transboundary issues and solutions, a focused, facilitated dialogue needs to be initiated. For this purpose, it is important to elaborate appropriate materials to foster the discussion in the workshop and to instruct a number of facilitators so that they may be prepared prior to the working group sessions.

Knowledge of the most typical trade-offs and dynamics, such as conflicting seasonal water needs for hydropower and irrigation, water quality degradation and clean water needs for drinking and sanitation, will certainly help analysts in their assessment, but an effort should be made to keep an open, diagnostic and participative approach during the first steps of the desk study (steps 1–3). This is needed to ensure that the assessment will capture the specificities of the basin, thereby providing a basis for ad hoc solutions.

It should also be noted that an exchange about the findings and possible follow-up actions can continue beyond the current assessment in the framework of the Water Convention or other initiatives, possibly adding significantly to the value of the exercise.

STEP 1
Identification of basin conditions and the socioeconomic context

The first step is to set up the basis of the desk study that will serve as a background document for the analysts during the workshop and the final nexus assessment. Ideally, the key documents to be taken into account should be identified by the national authorities. Practically, step 1 has a dual purpose, to identify:

(a) The needs of the population, mainly the population living in the basin area to meet basic human needs (such as water, food, energy and environmental security), poverty reduction or the improvement of socioeconomic conditions, economic development and a healthy environment, or to address factors that compromise human well-being in these terms. These needs may or may not be satisfied, which means people and local activities may or may not have access to the resources they need to develop.

(b) The relations between the region, the basin and the riparian countries. They are related to the economic activities that take place in the basin and to the natural resources that are found there, as well as how much the riparian countries rely on those resources for their overall economy. Resources or products developed from them can be exploited and transferred within or outside the region, while at the same time the local population may depend heavily on imported resources. These relations translate into regional and national development programmes and international agreements.

This step requires an understanding of the broad socioeconomic features of the countries, their administrative background and the resource base of the basin. For instance, a basin can be valuable for a country because of hydropower development or for the production of a specific crop; it can be the richest or the poorest area of a country, or it can be an important energy corridor. Similarly, resource management and economic activities in the basin can be related to the historical background of the countries and/or can reflect important policy directions or regional trends.

In order to pursue the double aim of this step efficiently (e.g. identify the needs of the population and the relations between the region, the basin and the riparian countries), it is advisable to proceed along two parallel, complementary paths, involving the necessary expertise. An analyst (or a team of analysts) should look at the basin and its population from the perspective of the availability of and access to resources. Another analyst (or a team of analysts) should look at it from a governance perspective and begin to define the institutional framework of the water, energy, agriculture/land use and ecosystems components of the nexus.[35] This involves mapping actors (ministries, State agencies, basin

[35] Water, energy, land use and ecosystems have often been referred to – even in the course of this project – as 'sectors' and sometimes as 'resources'. This ambiguity was justified by the fact that they could be considered either way, depending on the context of discussion. For clarity, they are here referred to as 'components' of the nexus.

organizations, regional and local authorities, and the private sector, including utilities and civil society) that influence the management of resources in the different areas of the nexus at the local, basin, national and regional levels together with their interrelations, which could be organizational structures as well as agreements and important joint efforts. The mapping also serves to identify key actors to involve in the assessment, in particular to participate at the workshops and for direct consultation. The governance analysis seeks to uncover potentially conflicting objectives of sectoral policies as well as shortcomings in administrative practice and philosophy that interfere with the resolution of such conflicts. At this stage, the mapping exercise is aimed at understanding the dynamics across scales (region, basin, countries). A more detailed mapping of actors will be further developed for each key sector in step 3.

In order to describe the natural resource base that allows a response (or not) to the needs, readily available and tested indicator sets are used. For an accurate assessment, basin or local level information would be ideal, but, in the case of many basins, national level information will need to be used as a proxy in the absence of more detailed data. A typical example is the lack of access to water and sanitation, which is normally only available at country or province level. These indicators can be complemented with quantitative and qualitative information at basin level or at a local administrative level.[36] The existence of a well-established basin organization that can compile and coordinate consistent statistics at the basin level will be very valuable, not only to obtain basin level indicators but also to estimate the accuracy of the proxies taken from national statistics. The degree of harmonization of data by national authorities varies greatly depending, for example, on the region and on the level of cooperation on information-sharing.

In parallel, the governance analysis needs to start with a mapping of actors, mandates and important regional dynamics, such as the relations of riparian countries with external economic and political players. In this first stage of governance analysis, it is possible to determine the main strategic goals that characterize the economies of the riparian countries. Owing to the broad spectrum of analysis – spanning from water governance to energy markets, to environmental management and agricultural development – the analysts would greatly benefit from existing sources of knowledge[37] about the basin and the region.

Helpful inputs for this step include the outcomes of a factual questionnaire screening the water, agriculture/land, energy and ecosystem resources. This first screening of the basin with information gathered directly from focal points[38] in the countries through a questionnaire inform the desk study that compiles relevant existing information and earlier studies. Particular attention is paid to documentation referred to by the participating authorities.

It is important to ensure meaningful communication between the two analytical paths because the information collected by the analysts in step 1 will form the basis of the desk study. Ideally, the analysts work in the same team with regular reviews of their findings, and sharing the ones that are of common interest while responding to each other's requests. For instance, the analyst looking at the basin from a resource perspective may recognize that there is an issue with energy access in rural areas. By knowing about this issue, the governance analyst could make sure to include the important actors (energy producers, utilities, regulators) in the mapping.

Outputs of step 1

The key outputs of step 1 were:

(a) Factual questionnaires targeting each riparian country.

(b) Responses to the questions:

  (i) What are the main issues faced by people living in the basin?

  (ii) What are the main economic activities taking place in the basin and that are relevant (for example in terms of resource provision) in the riparian countries or at the regional level?

  (iii) Who are the main actors and which strategies for development influence resource use in the basin?

Improvements to step 1

At the beginning of the nexus project (and the assessment of the Alazani/Ganykh River Basin), the governance analysis and the analysis of resources and needs were not sufficiently synchronized. The analysis of the basin was set up with a team of experts looking at the resources and needs to be complemented by a separate institutional analysis. This scheme was improved in the course of the project (in the assessments of the Sava and the Syr Darya basins), and the institutional analysis evolved into a concrete governance analysis, which covered not only institutional aspects but also the legal basis and the policy framework. Thus, enabling the other team to focus more on the physical aspects of the nexus. The dialogue was also improved between the two teams. A further improvement would be to strengthen the dialogue between the experts, ideally working in the same place with a common schedule. Assigning different teams of analysts to the development of a resource assessment and a governance analysis is unnecessary provided the team in charge of the nexus assessment possesses the requisite expertise. In addition, the economic aspects of the nexus – currently part of the governance analysis (see annex V) – would similarly benefit from the inputs of qualified experts.

The tools used in step 1 could also now be revised to make them more useful from the governance analyst's perspective and to avoid the duplication of efforts. In particular, the questionnaire included sets of screening questions mostly related to the availability of resources, socioeconomic conditions and economic activities in the basin, and environmental risks. In the assessment of the third basin (the Syr Darya), a similar questionnaire was prepared for the governance analysis and handed out at the workshop. For future assessments, it would be useful to merge the two questionnaires and to send the complete version to the stakeholders prior to the workshop so as to advance the investigation on governance issues and better align it with the overall assessment.

STEP 2
Identification of key sectors and stakeholders to be included in the assessment

In step 2, the needs identified are linked to key sectors and institutions based on their mandate and field of activity. The main purpose of this step is to identify which sectors and related institutions/actors need to be considered in the assessment process. These sectors will be analysed separately and in greater depth in step 3.

In view of the approaching first workshop and its follow-up activities, which depend on the stakeholders' active participation (steps 4–6), step 2 also helps to identify the key stakeholders. It

[36] An issue with collecting this type of information is that local data are often inconsistent or incomplete. For example, one country's share of a basin may coincide with an administrative unit for which national statistics provide useful information, while the other countries' shares do not overlap with a specific unit and/or statistics are not available to them.

[37] In addition to analysts' knowledge, local experts can be mobilized and earlier relevant studies drawn upon, as available.

[38] In the nexus assessment under the Water Convention, UNECE requested the main counterpart ministries responsible for water resources, to nominate a focal person from the national administration to the process. In addition, a local expert was engaged (in some cases by partner organizations) to support the process. Often it was the expert who filled out the factual questionnaire.

is important to involve a diverse and representative group of key actors and other stakeholders, including policymakers, experts and civil society who can contribute towards the assessment both with their knowledge and their power to take action. The key actors and other stakeholders to be involved include national and local government institutions of the main relevant sectors (most commonly water, energy and agriculture sectors), environmental protection authorities and, where feasible, local communities.[39] As appropriate, involvement of the private sector and civil society is also sought. In addition, involving experts who are engaged in relevant work in the basin is also highly beneficial. Relevant expertise includes work in the area of climate change adaptation, environment and governance, as well as current and past efforts to improve intersectoral cooperation between the water, energy and agricultural sectors in the region.

Outputs of step 2

The key outputs of step 2 answered the following questions:

(a) What are the key sectors that need to be analysed in depth in the nexus assessment?

(b) On the basis of organizations and actors mapped at regional and national scales: Who are the key stakeholders to involve in the assessment (in particular to participate at the workshops and for direct consultation)?

Improvements to step 2

Owing to the limited resources available in the nexus assessment project, as well as practical organizational constraints, as a priority the main ministries involved in the management of natural resources were engaged in the participatory process through their nominated representatives. As an improvement, it would be of great use to accurately identify the key stakeholders based on a governance analysis carried out sufficiently early on in the process. This would facilitate screening and thus ensure that the key stakeholders are taken into account, and possibly allow for greater involvement of the private sector. In particular, it would improve the work in the workshops if decision makers and policymakers from all the sectors concerned were better represented.

STEP 3
Analysis of the key sectors

In step 3, each of the key sectors identified in step 2 is analysed, following roughly the logic of the Driving forces-Pressures-State-Impacts-Responses (DPSIR) framework.[40] As mentioned earlier, the water, energy[41] and agricultural sectors form the core group of key sectors. Others may include a particular industry, tourism, navigation and sub-sectors of agriculture (e.g. fishing or forestry). It is important to ensure the representation of environmental protection interests, both environmental authorities and civil society groups working on the environment, in addition to economic interests.

In order to obtain information necessary for the nexus approach, the following four dimensions of each sector need to be qualitatively stepped through:

(a) Drivers: needs, incentives, policies and programmes:

  (i) It is possible to identify at this stage a set of key policies, development targets, new laws and institutional changes to be associated with the key sectors. Many drivers are national (e.g. sectoral policies), but there can also be important drivers at the regional and basin levels (e.g. customs unions, regional development programmes). Fulfilling the basic needs of the population, such as access to safe water, clean energy and sustainable livelihoods, is also part of this group.

  (ii) From the user's perspective, important financial drivers are tariffs, incentives, subsidies and regulations. Depending on the legal and economic basis (which could be more State-oriented or more market-oriented, more centralized or more decentralized) these could play a major or minor role.

  (iii) Because of regional developments and national sector priorities, important pulls between these and local basin needs and constraints might be observed. Thus, common or contradictory transnational trends might also be uncovered.

(b) Pressures and impacts: effects on the environment and the impact on humans and ecosystems. The sectors contribute to the economy by meeting local needs and achieving national objectives. Here, the services each sector provides and what impacts they have should be considered. For example, safe drinking water is a "service" supplied by the water sector. An impact of the sector might include depletion of water resources owing to heavy abstraction. Poor health of the population may be a resulting impact of inadequate water sector management;

(c) Setting (state):

  (i) Flows and physical setting. The resource base and how the sectors use resources (water, energy and land) should be considered. Developing a proper integrated analysis of the dynamics between the resources and their uses has not been a part of the assessment. However, it could be, upon expression of interest and depending on the resources available, through a follow-up project. At this stage it is important to sketch the main qualitative and quantitative aspects that would characterize such an analysis. This would involve:

[39] Due to the highly variable number of riparian countries and the size of the basins, the extent of stakeholder involvement inevitably varies. Because of the interactive format of the basin assessment workshop, there may also be some practical limitations regarding the number of participating stakeholders.

[40] The DPSIR framework was adopted by the European Environment Agency and is broadly used under the Water Convention. For details, see: EEA. *Environmental indicators: Typology and overview*, Technical report No. 25 (Copenhagen, European Environment Agency, 1999). Available from: www.eea.europa.eu/publications/TEC25/

[41] The water and energy sectors include the production or extraction, distribution and management of resources, utilities and institutions.

a. A spatial analysis of the basin, using geographical information systems (GIS) to determine basin borders, main land use types, the location of important ecosystems and key infrastructure.

b. The development of a reference energy system to map energy resources from the source to the main uses in the riparian countries;

c. The definition of a hydrological model[42] of the basin.

d. An understanding on the main ecosystems (e.g. glaciers, wetlands, forests, etc.) and the services they provide.[43]

(ii) Institutions and governance. Looking at each sector, the institutional and legal framework is reviewed and the organizations and actors are presented in the form of a graphical scheme. Drawing from the previous efforts (step 1), intersectoral, local-national as well as transnational agreements and mechanisms are now presented in terms of sectoral institutional settings and activities. This will allow the analyst to study and compare mandates and responsibilities, as well as identify institutional gaps or dysfunctional mechanisms that need better coordination. The assessment of institutions in general,[44] and organizations in particular,[45] allows the mapping of tensions that might emerge between upstream and downstream countries based on uses between sectors within a country, or between local and national authorities within a country. It also allows inference of where there might be gaps in the legal basis or inadequate coherence between policies.

(d) Solutions and related constraints (management response). In this step, possible activities aimed at reducing pressures and impacts for each sector are spelled out. The broadest view of possible options should be aimed for, making reference to efforts already under way to achieve the opportunities highlighted. Solutions can be of various types, for example: policies, infrastructure-related coordination arrangements or economic instruments. Hence, both the governance and technical perspectives help in identifying them. It is important to determine which solutions would have the greatest impact and most beneficial effects, as well as which solutions seem most feasible financially and/or politically. It is also valuable to recognize the solutions that would be difficult to implement and why.

Outputs of step 3

The key outputs of step 3 were:

(a) A good understanding of the sectors, their resource needs and impacts;

(b) A water, energy and land resource assessment, including information on their availability and quality (as detailed as possible);

(c) An understanding of the most critical environmental issues in the basin and of the indirect impact on human activities through the degradation of ecosystem services;

(d) An overview of the following governance related elements:

(i) Institutional and legal framework. Identification of where there may be incoherence and potential for conflict.

(ii) Mapping of actors at sectoral and subsectoral scales.

(iii) Set of key policies and development targets.

(iv) Regulatory and economic instruments (tariffs, incentives, subsidies and regulations).

(e) A set of indicators available to substantiate items (a) to (c) above;

(f) Four thematic GIS maps to facilitate the discussion at the workshop (energy, water, agriculture/land use and ecosystems);

(g) Identification of activities in place to reduce pressures and impacts (laws, policies);

(h) Data gaps to be addressed by experts and country representatives.

Improvements to step 3

It can be valuable to ask country experts for a review of the key policies collected, development targets, new laws and institutional evolutions. During the first basin assessments this aspect was improved by explicitly requesting the presenters at the first workshop to provide a set of key policies divided by the components of the nexus. Ideally, the key policy documents should be available to the analysts before the workshop.

The extent to which the analysis of natural resources varied in the three basins already assessed was influenced by the availability of data and access to tools and resources. Even though it was not strictly part of the envisaged process it became clear that limited modelling was needed to be able to provide illustrative quantification of interlinkages across sectors. In future assessments, the need for such modelling should be foreseen. If there are specific issues that the countries want to look at, quantification can be focused on the issue at stake, ideally using already available models and liaising with local research institutes. A modelling exercise can be also valuable to advance capacity-building.[46]

[42] The development of a hydrological model is highly time- and resource-consuming. In many cases, a hydrological model is already available and can be used as a reference. If not available, possible development by the analysts should be carefully considered on the basis of the level of detail that the assessment should reach in terms of quantification of trade-offs.

[43] According to the many classifications, ecosystems services are divided into four groups: provisioning, supporting, regulating and cultural. For definitions and examples, see: 'Ecosystems Services' on the TEEB website: www.teebweb.org/resources/ecosystem-services/

[44] Institutions are defined in a very broad sense. In *Institutions, Institutional Change and Economic Performance* Douglass North observes that they "provide the rules of the game for human interaction" (Political Economy of Institutions and Decisions series, Cambridge University Press, 2009). As a result, the Global Water Partnership (GWP) observe in their IWRM report (2000) that "Institutional development is not simply about the creation of formally constituted organizations (e.g. service agencies, authorities or consultative committees). It also involves consideration of a whole range of formal rules and regulations, customs and practices, ideas and information, and interest or community group networks, which together provide the institutional framework or context within which water management actors and other decision-makers operate".

[45] Organizations such as ministries or river basin organizations on the other hand are more rigid and visible than institutions: theoretically, they can be defined as structures performing recognized and accepted roles, created intentionally within the existing web of institutions to serve a certain purpose.

[46] This is especially the case if freely available modelling tools are used, to which the local experts and officials would still have access later on.

It should be mentioned that – as a limitation – it is easier to verify whether the more static elements of governance are in place (such as transboundary agreements and their scope, organizations and their official mandates) as well as adherence to UNECE instruments, which are drivers of good governance. Unfortunately however, more dynamic elements related to, for example, the implementation of policies and actual power relationships between countries and institutions (tacit or explicit) would not necessarily be captured at this level of application.

As a further step, an identification of specific hotspots in the nexus was proposed to analyse the main rivalries between actors in their use of resources, and to understand how tensions are regulated. Resource use rivalries depend on resource scarcity, which can arise either from resource quantities being effectively limited (absolute rivalry) or when resources are sufficient and available but sharing arrangements deprive some users (relative rivalry). A rivalry over resources does not necessarily become a conflict over use. It tends to remain non-confrontational as long as a regulatory framework determines the distribution of uses in a coherent and balanced manner.[47] A further development of the governance analysis could study the kinds of governance solutions that are needed to address nexus hotspots.

STEP 4
Identification of intersectoral issues

Step 4, the identification of intersectoral issues, is carried out in the framework of a first participatory multisectoral workshop.

The general structure of the first workshop is provided in annex III. A representative set of the relevant actors identified in step 2 (officials, other key stakeholders and experts) should participate. The desk study (steps 1–3) serves as a background document for the analysts during the workshop and helps shape the type of discussion that will take place.

The opinions of the participants are collected so as to appreciate the differences in perspective by country and sectoral affiliation. These can be presented in the course of the workshop to show the areas of common agreement as well as the different viewpoints from the different sectors or countries.[48]

Selected thematic or regional overview presentations, as well as an overview of the sectors and national policy developments from the riparian countries (see annex IV), are used to set the stage at the beginning of the workshop.

Participants at the workshop are then divided into sectoral groups[49] to focus on and analyse each component of the nexus. They are asked to consider the component's sectoral plans (including the time frame) and their links to other components as resource input requirements (for example, the energy sector's water needs for hydropower generation or cooling).

The key activity in this step is for participants to consider linkages of their sector with other sectors and the implications thereof. Relevant intersectoral relations and impacts from each sector's point of view are noted. The discussion can then be extended to where in the basin the interlinkages are most prominent by looking at a thematic GIS map of the basin. Thematic presentations for each sectoral group can be prepared on the basis of the desk study to kick-start the discussion.[50]

As an example, the land use group may draw an arrow from energy to land use to indicate that hydropower production reduces the available water supply, thereby limiting irrigation potential. The same group could also draw an arrow from land use to ecosystems to indicate the effect of agricultural discharges.

The participatory aspect of this step is important to ensure that the local knowledge in the countries and in the basins points to the most relevant and pressing intersectoral issues. This provides a basis for an intersectoral (nexus) dialogue. Each group is empowered to present the integrated nature of their component in the next step.

Outputs of step 4

The key outputs of step 4 were, for each sectoral group, an integrated sector diagram linking the component in focus with the others by means of explicit resource input needs, impacts and effects (figure 4).

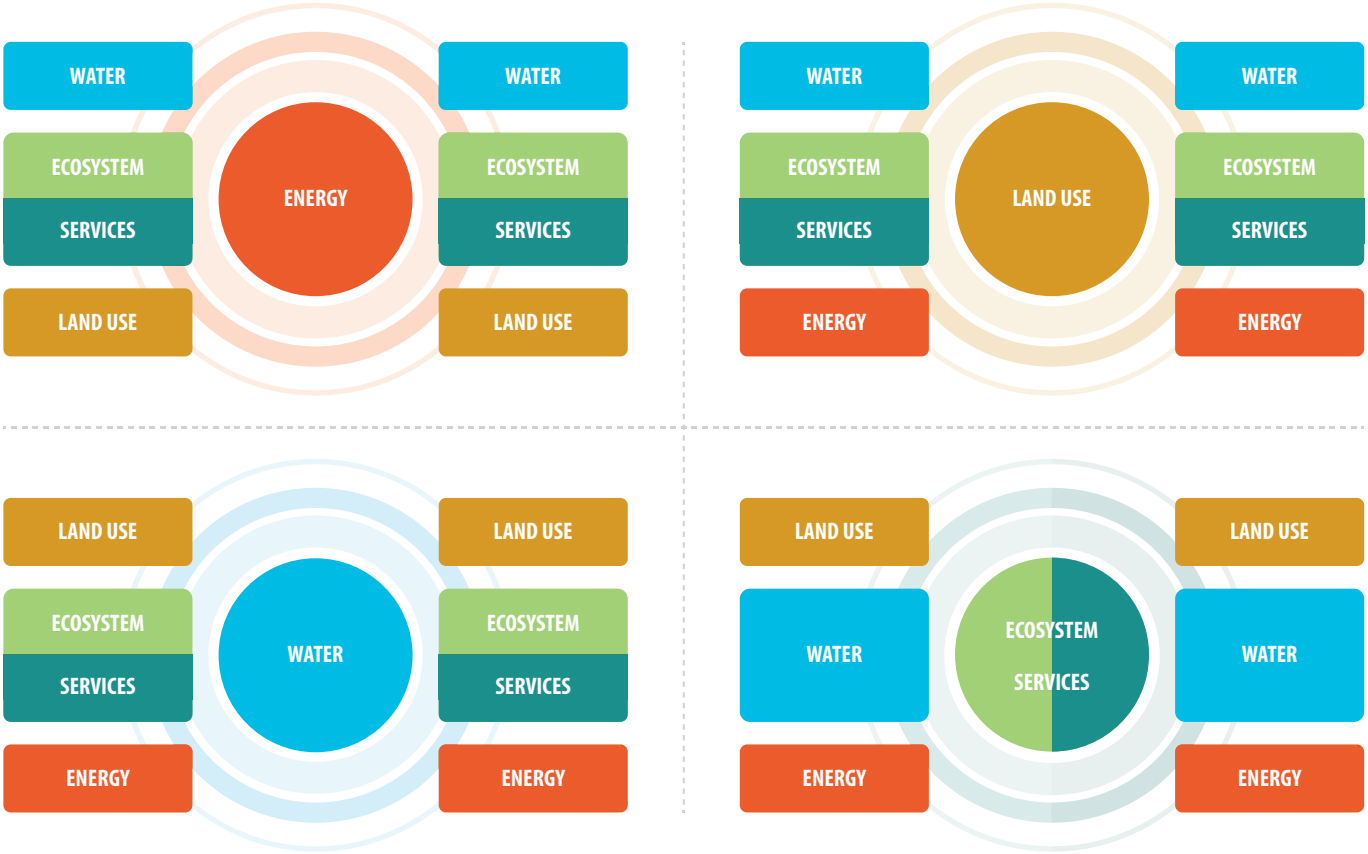
[47] See original document, A draft methodology for assessing governance aspects of the water food-energy-ecosystems nexus by Dr. Christian Bréthaut, University of Geneva, presented at the second meeting of the Task Force on the Water-Food -Energy-Ecosystems Nexus. Available from: www.unece.org/index.php?id=34460

[48] The opinion-based questionnaire is reproduced in section 7 (Opinions of Countries and Sectors) of the document, Water Food-Energy-Ecosystems Nexus: Reconciling Different Uses in Transboundary River Basins, presented at the second meeting of the Task Force. Available from: www.unece.org/index.php?id=34460

[49] For simplicity's sake, the groups are called 'sectoral' although they are defined on the basis of the four areas of the nexus (water, energy, agriculture/land and ecosystems). The key sectors identified need to be assigned sensibly to one of these four areas. For example, tourism could be well integrated in the discussion around ecosystems, while agriculture (including forestry) would probably lead the discussion on land use.

[50] This was tested in the workshop on the Syr Darya River Basin and proved to be useful for the energy group.

FIGURE 4
Diagrams of each sectoral group for the purpose of identifying intersectoral issues



Improvements to step 4

The future dimension was not explicitly considered in this step in any of the workshops. If a clear list of key policies is available for each group, the sectoral groups could be asked towards the end of the session to comment on how those policies – each sector will have its own – will affect the identified interlinkages.

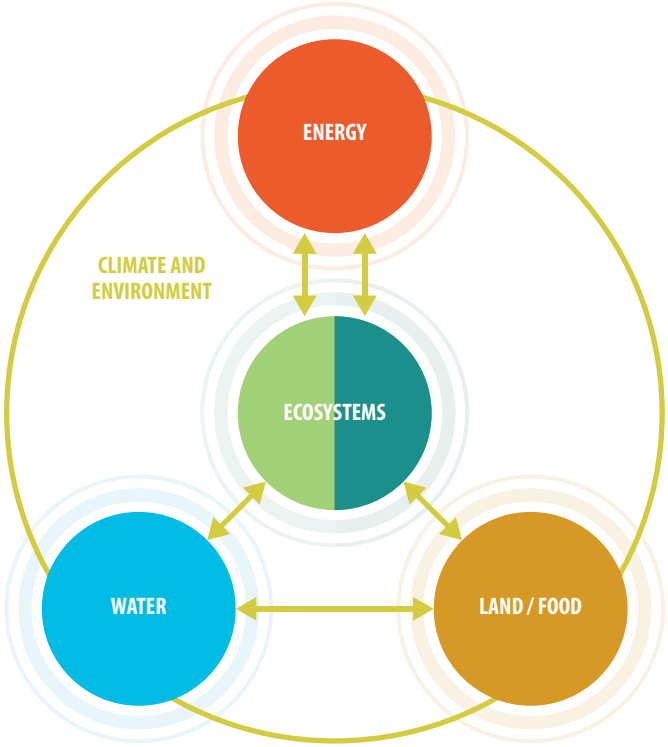
STEP 5
Nexus dialogue

A nexus diagram (figure 5), including links between sectors, is drawn collectively in the first workshop. This shows all sectors as being equally important. Links identified in step 4 from a sector perspective are considered in step 5 and jointly prioritized. The links might be unidirectional (impact of one sector on another) or bidirectional (trade-offs, affecting each other).

This part of the first workshop evolved significantly from the pilot to the last workshop. At the beginning, a second working group session (in sectorally mixed groups) was established to build consensus on a set of priority interlinkages. Later, this session was made shorter and prioritization was realized in an interactive plenary session. This allowed the allocation of more time to working groups to discuss the future dimension in another session.

At the next workshop activity, the relevant future tendencies are identified jointly with the participants: scenarios are developed, and the effects between sectors are qualitatively described. This was initially done in very general terms with discussions in plenary session on socioeconomic trends (population growth, economic development, etc.), strategic directions of the sectors, priorities of the countries and external constraints, such as climate change. In the last workshop, an attempt was made to focus this discussion more on the future dimension and to make it more interactive. It was decided to take one session and use it to build scenarios in working groups so as to define key uncertainties and discuss the evolution of the identified interlinkages in those scenarios.

FIGURE 5
Nexus dialogue: agreed key interlinkages



Outputs of step 5

The key outputs of step 5 were:

(a) An agreed set of priority interlinkages across sectors;

(b) Agreed scenarios to be considered in the assessment;

(c) Identification of key uncertainties and drivers of change;

(d) A preliminary (qualitative) understanding of the evolution of the interlinkages under the agreed scenarios.

Improvements to step 5

In the last workshop[51] that discussed the future dimension, the working group session was designed on the basis of the "Scenario Thinking" exercise developed by the FAO.[52] According to the FAO, in previous applications this exercise was carried out for the entire duration of a workshop and achieved very satisfying outcomes. While the time was reduced to three hours, the procedure was not sufficiently modified to fit such a short time slot. In future applications, this session will need to be redesigned and its required outputs better defined.

STEP 6
Identification of synergies (across the sectors and countries)

In step 6, some possible solutions to the most pressing intersectoral issues are identified. Solutions could be of various kinds, including, for example:

(a) Policy solutions (changes to existing policies or new policies);

(b) Land use management (planning and change of practices), measures and practices;

(c) Cooperation agreements (institutional arrangements, trade, etc.);

(d) Technology, operation and infrastructure (new investments, changes in infrastructure operation);

(e) Coordination and communication (e.g. capacity-building, common databases);

(f) Economic instruments (market-based or regulatory).

For the purpose of the short summary assessments presented in this publication, the possible solutions were grouped into the following five categories: institutions, information, instruments, infrastructure and international coordination and cooperation.

Solutions discussed need to benefit at least two different sectors and have a clear transboundary dimension. Discussion about their feasibility, advantages and limitations, as well as possible practical actions in response to the assessment's findings, is ideally taken further with stakeholders at the second workshop.

If possible, the thinking and dialogue should be prolonged to explore who (which sector, organization, etc.) is in a position to address the potential solutions identified, and what concrete actions could be undertaken by which actor. Actions could be incorporated into ongoing or planned initiatives. For instance, in some basins the riparian countries are part of the European Union (EU) Water Initiative's National Policy Dialogues (NPDs) or there are regional organizations, such as basin organizations or other joint bodies, possibly with multiple-sector representation that could provide a framework for identification of beneficial future activities. The potential benefits of such options for cooperation across sectors and countries could be substantiated wherever there is enough data to support it with explicit calculations (for example, savings of water or energy that are feasible to obtain).

The participatory workshop provides a good forum to brainstorm such solutions as they naturally arise from the discussion on intersectoral issues. At the same time, it is difficult to expect the discussion to evolve into detailed solutions at this stage, not only because the workshop would probably be overloaded, but more importantly because a more in-depth analysis of the jointly identified issues, trends and solutions is needed before proposing concrete actions.

The in-depth analysis of interlinkages is to be carried out by the analysts. Limited quantification of intersectoral issues and the benefits arising from the solutions suggested is possible but constrained by the resources available. A qualitative identification of benefits is nevertheless possible. Identifying clear benefits for the sectors and the countries is key to pursuing the final objective of the assessment, which is to find entry points to existing or new policies and legislation or other concrete measures to address the intersectoral issues identified.

In general, the nexus approach adds value in the sense that it can help uncover the co-benefits (or external costs) associated with actions in one sector, thus providing important insights at the local and national level as well as across boundaries.

Transboundary water cooperation has the potential to generate diverse and significant benefits for cooperating countries. Those benefits can be realized by accelerating economic growth, increasing human well-being, enhancing environmental sustainability and contributing to political stability. Commonly the understanding of possible benefits is narrowly focused on sharing (volumes of) water. The intersectoral or nexus approach invites consideration of the intersectoral implications of policies and management measures, and the related opportunities for benefits in a broad sense. Assistance in recognizing wide-ranging benefits is available from the Policy Guidance Note on Identifying, Assessing and Communicating the Benefits of Transboundary Water cooperation[53], developed under the Water Convention.

[51] The first nexus assessment workshop on the Syr Darya River Basin was held in Almaty, Kazakhstan from 2 to 4 December 2014. More information is available from: www.unece.org/index.php?id=37579

[52] FAO. *The Water-Energy-Food Nexus: A new approach in support of food security and sustainable agriculture* (Rome, Food and Agriculture Organization of the United Nations, 2014). Available from: www.fao.org/nr/water/index.html

[53] UNECE, *Counting Our Gains: Policy Guidance Note on Identifying, Assessing and Communicating the Benefits of Transboundary Water Cooperation* (New York and Geneva, United Nations, 2015).

TABLE 3
Typology of the potential benefits of transboundary water cooperation

Origin of benefits	Benefits for economic activities	Benefits beyond economic activities
Improved water management	**Economic benefits** • Expanded activity and productivity in economic sectors (aquaculture, irrigated agriculture, mining, energy generation, industrial production, nature-based tourism) • Reduced cost of carrying out productive activities • Reduced economic impacts of water-related hazards (floods, droughts) • Increased value of property	**Social and environmental benefits** • Health impacts from improved water quality and reduced risk of water-related disasters. • Employment and reduced poverty impacts of the economic benefits • Improved access to services (such as electricity and water supply) • Improved satisfaction due to preservation of cultural resources or access to recreational opportunities. • Increased ecological integrity and reduced habitat degradation and biodiversity loss • Strengthened scientific knowledge on water status
Enhanced trust	**Regional economic cooperation benefits** • Development of regional markets for goods, services and labour • Increase in cross-border investments • Development of transnational infrastructure networks	**Peace and security benefits** • Strengthening of international law • Increased geopolitical stability and strengthened diplomatic relations • New opportunities from increased trust (joint initiatives and investments) • Reduced risk and avoided cost of conflict and savings from reduced military spending

Source: UNECE, Policy Guidance Note on the Benefits of Transboundary Water Cooperation: Identification, Assessment and Communication (New York and Geneva, United Nations, 2015).

Following the in-depth analysis of interlinkages, the analysts and the stakeholders should meet again to discuss opportunities to take action.

Outputs of step 6

The key outputs of step 6 were:

(a) A set of potential actions that can be considered as "nexus solutions", which means they have clear cross-sectoral benefits and transboundary dimensions;

(b) The identification of existing or potential policies and actions that could provide a vehicle for the implementation of such solutions. This would naturally lead to answering the question of who could take action.

Improvements to step 6

Although not initially included among the elements of the methodology, a follow-up meeting with the countries (or second workshop) naturally emerged from the original process as a forum to discuss findings and the realistic application of nexus solutions. It is now recognized to be one of the key moments of the nexus assessment. Such follow-up workshops have been held as side events of the NPD meetings (co-organized by UNECE and the Organization for Economic Cooperation and Development) in the countries of the Caucasus and Central Asia, but these have been national. A transboundary stakeholder consultation workshop was organized on the findings of the nexus assessment of the Sava River Basin.[54]

The assessment seeks to identify a broad range of possible beneficial, synergic actions. However, detailing the technical and economic feasibility, risk and resilience as well as costs and benefits is beyond the scope of the assessments carried out from 2013 to 2015. Follow-up analysis would be necessary to look into these aspects.

Use of indicators

The nexus assessment of each basin is data dependent and indicator based. Figure 6 shows how indicators and data relate to the six steps of the basin assessment, and table 4 describes the three sets of indicators used.

The information provided by the national administrations in the riparian countries is the preferred source of data.[55] Where information is already available, as reported by national authorities or as country statistics, it is gathered directly.

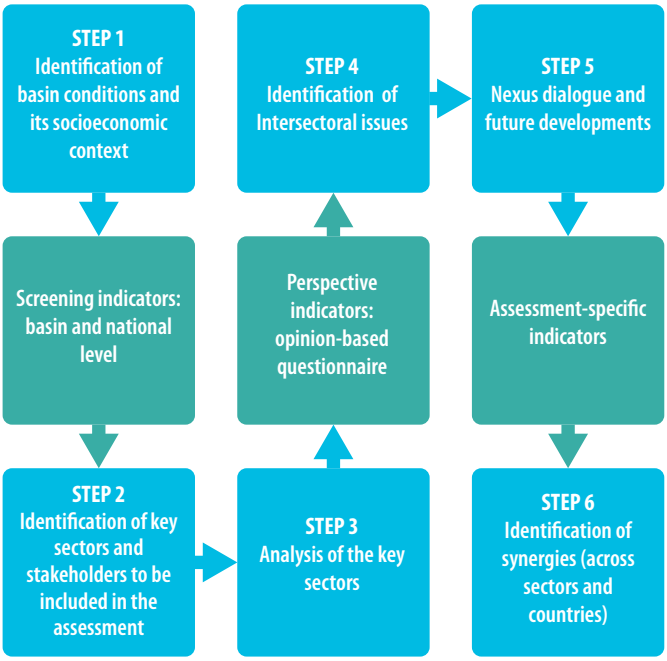
The analysis evolves from a diagnostic analysis (zooming in on the key sectors) of the basin and the riparian countries to a participatory phase where intersectoral issues are discussed together before proceeding to an analysis of the main issues identified and potential synergic solutions. Thus, a first set of indicators helps in the diagnosis of the basin. These might be available at national or basin level depending on the topic. The historical or spatial variation of indicators and information is considered whenever relevant (e.g. water quality can be different from point to point; access to safe water can be increasing, decreasing or stable) and whenever available (often, data at basin level are simply not available or they partially overlap with regional or district level data). This group also includes the nexus indicators of FAO that specifically look at the interlinkages across pairs of components (water-energy, food-energy and water-food) and their trends.

It is important to keep in mind that a comprehensive list of indicators is difficult to establish as a nexus assessment does not have a predefined focus. Rather than trying to collect all possible information, the analyst should adopt a critical approach during this screening. If something is relevant, further indicators should be looked at. As an example, knowing that a country has a large share of land cultivated with a certain crop, the analyst may be interested in establishing the part of the gross domestic product that comes from the export of that particular crop. An effort has been made in the assessment under the Water Convention to use the indicators for the purpose of visualizing and comparing different basins, but in the end few common indicators for all basins have been used. Not all indicators will be comparable for all basin assessments but, for the purpose of this exercise, it has been more important to focus on what is relevant in each case rather than ensuring comparability.

[54] The consultation workshop was organized with the support of the German Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, and the German Federal Environment Agency.

[55] To facilitate the process, national experts or coordinators engaged in the assessment support information collection and liaison with the focal points.

FIGURE 6
Indicators (in green) and how they are used in the steps (in blue)



A second set of indicators consists of the evaluation of the importance of issues occurring in the basin according to the opinion of participants in the nexus assessment process. The questions are divided into four general groups: water, energy, agriculture/land and ecosystems. The answers are kept anonymous given the nature of the questionnaire, but each person answering has to specify if they are an expert in water, energy, agriculture/land or ecosystems, and which country they represent in order to allow for comparisons. The indicators developed from the analysis of this questionnaire consist of comparisons between the opinions arising from the different countries or the different perspectives (the components of the nexus).

The third set of indicators and data is the most variable in terms of type and use. These indicators will be needed to validate statements, substantiate qualitative analysis and to calculate intersectoral benefits. These are difficult to meaningfully predict beforehand.

A list of indicators and sources is presented in annex II. It is important to keep in mind that the nexus assessment needs to move across scales. Occasionally indicators will be available at the national, basin, sub-basin or even local level. Very often, it will be difficult to obtain information that specifically refers to a country's share of the basin. This will probably require the use of proxies, highly aggregated data and partial information.

TABLE 4
Indicators: types and uses

Group	Screening indicators	Perspectives indicators	Assessment-specific indicators
Type	**National indicators**		
	Socioeconomy, demography, poverty, environment, access to resources. Resource base:[a] availability, quality and uses at basin level. Resource uses and intensity.[a] World Development Indicators: Progress towards Millennium Development Goals, demography and society, environment, economy, States and markets.	Issues related to energy, water, land use and environment according to local authorities (that have good knowledge of the basin). The opinions are in the form of ranking (very important to not important, high intensity to low intensity of impact).	
	Basin indicators (including GIS)		
	Geospatial analysis: land use types, location of important ecosystems and key infrastructure. Resource base:[a] availability, quality and uses at basin level. Resource uses and intensity.[a] Indicators related to water resources and uses.	Used to appreciate the differences in perspective by country and by sectoral affiliation. These can be presented in the course of the workshop to show what everyone agrees on and what is viewed differently from different sectors or countries.	Indicators related to basin-specific issues and solutions. These can be quantitative, qualitative, or semi-quantitative. If specific indicators are not available, national and basin indicators can be used as proxies.
Use	Used in the initial phases of the assessment. If needed, they can be validated or adjusted via country/stakeholder consultations. At basin level, data available can differ greatly in terms of level of aggregation, accuracy, reliability, etc. In a final stage of the assessment, if better data is missing, they can be used as proxies for potential calculations. Data on energy and water consumption by sector are also used to determine their energy efficiency and water efficiency. Qualitative and semi-quantitative indicators can be very useful information to complement the indicators (for example, types of groundwater use in the basin or water quality).		Used to substantiate the in-depth analysis of the issues and solutions identified. Wherever possible, their quantification can help determine the major issues across sectors and the costs and benefits of synergic solutions. Given the specific focus of the in-depth analysis, the type of evaluation and/or quantification depends largely on the data available.

[a] Resource uses and availability are relevant both at the national and basin levels to understand how dependent the riparian countries are on the basin (e.g. percentage of energy produced in the basin).

Going a step further: tools and analysis methodologies available for quantifying the nexus

There may be interest in pursuing further opportunities in the water-food-energy-ecosystem nexus and this section will present some existing tools to that end. Several nexus tools and approaches have been developed, and more are being developed[56] to assess the nexus at different scales and for different purposes. These include: (1) dialogues; (2) mapping; (3) scenarios; (4) extended systems analysis; and (5) institutional analysis. This section will introduce each of these components. Reference is made to elements in the UNECE nexus assessment methodology that have some similar features.

As highlighted in the review, the user friendliness of the toolkits available differs; they either cater for detailed specialist work or for visualization of pre-run results by non-specialists. The input data intensity of tools also varies, typically depending on the policy question being asked and the resulting calculations required. For policy design and assessment of the intersectoral impacts of plans and projects, detailed quantification of effects is likely to be needed.

Nexus dialogues

Nexus 'dialogue initiatives' range from fora to the collection of case studies, the dissemination of information and the active engagement of a range of different stakeholders. These include, among others: the Water, Energy and Food Security Nexus Platform[57]; IUCN nexus dialogues[58]; national inter-ministerial panels[59]; multi-disciplinary networks[60] and regular conferences, such as the FEWS (Food-Energy-Water-Security) Challenge symposia.[61] In addition to other initiatives, they help develop a dialogue between actors that normally operate with divergent perspectives and at different levels and scales. While often not explicitly articulated, their efforts range from sharing insights to developing a common vocabulary and promoting policy coherence. In the UNECE nexus methodology, a focused dialogue with identified stakeholders and sector plans takes place as part of the first workshop.[62]

Nexus mapping

Mapping interactions between sectors with an aim to modelling them was popularized in *The Limits to Growth*.[63] In integrated energy planning such mapping, known as a Reference Energy System (RES) diagram, is common. This has been extended to Climate change, Land-, Energy and Water-use (CLEW) nexus schemes.[64]

In the UNECE nexus methodology, mapping takes a two-step approach. Initially sector officials and experts map the interactions of their sector to another sector using diagrams with lines drawn between symbolic sector representations with each line indicating a physical linkage. The mapping facilitates the identification of key connections and constraints between sectors.

Multi-resource scenarios and extended systems analysis

Various efforts have and are being developed to help quantify linkages between systems, which are then used to understand current and future interactions. In that section, models are divided into (i) geographical scope; (ii) data intensity; (iii) modelling/technical capacity required; and (iv) linkages. As observed by United Nations Department of Economic and Social Affairs (UNDESA) at project level,[65] there are multiple examples of integrated analysis of resource use, many of which are mandated such that at the regional scale there are a moderate number, and at the national level there are few (see table 5). Of interest in this work under the Water Convention is a simultaneous combination of all three scales: subnational, national and regional (transboundary).

[56] Mark Howells and Holger Rogner. (2014). Water-energy nexus: Assessing integrated systems. *Nature Climate Change*, vol. 4, pp. 246–247.

[57] Information available from: www.water-energy-food.org/

[58] IUCN and IWA, *Nexus Dialogue on Water Infrastructure Solutions* (Gland, International Union for Conservation of Nature and International Water Association, 2015). Available from: www.waternexussolutions.org/1x8/home.html

[59] Mark Howells and others (2013). Integrated analysis of climate change, land-use, energy and water strategies. *Nature Climate Change*, vol. 3, pp. 621–626.

[60] Information available from: www.thenexusnetwork.org

[61] Khon Kaen University (KKU), The 2014 Annual FEWS (Food, Energy, Water, Security Challenge) Symposium. Symposium website: http://fews2014.kku.ac.th/

[62] This begins in steps 1–4 of the methodology: (1) Identification of basin conditions and its socioeconomic context; (2) Identifying key sectors and stakeholders; (3) Analysis of key sectors; and (4) Identification of intersector issues.

[63] Donella H. Meadows, Dennis L. Meadows, Jørgen Randers, William W. Behrens. *The limits to growth* (New York, Universe Books, 1972).

[64] IAEA, Annex VI: Seeking sustainable climate, land, energy and water (CLEW) strategies. In *Nuclear Technology Review* (Vienna, International Atomic Energy Agency, 2009). Morgan Bazilian and others (2011). Considering the energy, water and food nexus: Towards an integrated modelling approach. *Energy Policy*, vol. 39, No. 12, pp. 7896–7906.

[65] UNDESA. *Global Sustainable Development Report: Sustainable Development Knowledge Platform*. (United Nations Department of Economic and Social Affairs, 2013) Available from: http://sustainabledevelopment.un.org/index.php?menu=1621#tools

TABLE 5
Integrated assessments at different levels and their application

	Subnational	National	Regional and global
Project	Environmental Impact Assessment (EIA) and Environmental and Social Impact Analysis is almost universal and widely mandatory		EIA at the transboundary level is an obligation for Parties to the Espoo Convention[a]
Programme and Policy	Many programmes are subject to Strategic Environmental Assessment (SEA)[b] (beyond industrialized countries)	SEA is mandatory in Europe and in various countries in other regions, and supported by international financing institutions (e.g. the World Bank and ADB) and other expert and advisory bodies	Poverty Impact Assessment in use by development banks (e.g. ADB), global funds, a number of international organizations (e.g. OECD), and development assistance agencies; Poverty and Social Impact Analysis is used by the World Bank and promoted by the UN Department of Economic and Social Affairs (UNDESA)
Sector	Conventional sectoral planning; many sectoral and land-use plans are subject to SEA (beyond industrialized countries)	Conventional energy and infrastructure planning	Many energy, land-use and water models
Multisector	Significant number of academic applications	Few examples: Recent CLEW case studies[c]	Moderate number of integrated assessments

Source: Adapted from UNDESA, Stylized review of integrated assessment practices, *Global Sustainable Development Report, 2014 Prototype edition* (New York, United Nations Department of Economic and Social Affairs, 2014). Available from: https://sustainabledevelopment.un.org/globalsdreport/2014

[a] Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention). Information available from: http://www.unece.org/env/eia/eia.html

[b] Box 5 in chapter 2 can be referred to for more information on SEA.

[c] Refer to the following for an example from Mauritius and Burkina Faso, respectively: box 1 in chapter 2 (Mauritius); Sebastian Hermann and others (2012). Climate, land, energy and water (CLEW) interlinkages in Burkina Faso: An analysis of agricultural intensification and bioenergy production. *Natural Resources Forum*, vol. 36, no. 4, pp. 245–262.

Building on CLEWs framework,[66] the UNECE nexus approach identifies interlinkages and then applies fit-for-purpose toolkits, typically based on existing models with some soft linkage between them.

Institutional analysis

Mapping institutions have become a recent focus in multi-resource studies.[67] This is of particular importance given that the chain of activities from resource to food-, energy- and water-services governance may be divergent. Mandates of organizations for oversight may overlap or may be missing, or organizations may have competing goals or have different levels of influence. This can result in mismanagement and the poor allocation of resources or distortions. In the UNECE nexus approach, an approach to analysing the governance aspects of the water-food-energy-ecosystems nexus has been developed that focuses on policy, law and organizations in the nexus. Chapter 3 of this report on the methodology can be referred to for more details.

[66] Mark Howells and others (2013). Integrated analysis of climate change, land-use, energy and water strategies. Nature Climate Change, vol. 3, pp. 621–626. IAEA, Annex VI: Seeking sustainable climate, land, energy and water (CLEW) strategies. In *Nuclear Technology Review* (Vienna, International Atomic Energy Agency, 2009).

[67] Sergio Villamayor-Tomas and others (2015). The Water-Energy-Food Security Nexus through the Lenses of the Value Chain and the Institutional Analysis and Development Frameworks. *Water Alternatives*, vol. 8, pp. 735–755.

Contemporary approaches to multi-resource scenarios and extended systems analysis

A key focus of this chapter is a scan of existing and developing toolkits or approaches. Some of their general features are discussed below.

These toolkits fit loosely into: (i) fully integrated multi-resource models;[68] (ii) extended (single system) models;[69] and (iii) soft-linked models.[70] These may account for varying amounts of system interaction, and often the toolkit and approach are synonymous. The UNECE approach allows for flexible toolkit choice depending on the question at hand.[71]

There are existing stand-alone and limited multi-resource modelling tools available. The extent to and technique by which each resource is represented is often dependent on the type of question posed. At a global level, simple resource accounting already provides insights,[72] while detailed hydrological models may be required when focusing on constraints associated with watercourses.[73] Should the focus be economic macroeconomic impacts then structural economic impacts need to be reflected.[74] If the focus includes threats then special model features may be required. Not all hydrological models will simulate flood impacts, however, the one used for the nexus assessment of the Sava River Basin by the JRC does.[75] Further, scales of recent applications vary from global[76] to regional[77] and national.[78] At subnational level, policy relevant applications are emerging.[79]

Toolkits are more or less user-friendly and more or less data intensive. Often this is a function of the question being asked and the resulting calculations required. In the case of user friendliness however, special efforts have been made by some toolkits to provide easy entry, while allowing the user to build complex models such as WEAP-LEAP. Data requirements can be demanding, even for user-friendly tools. They may include the need for large quantities of river flow and rainfall data to calibrate hydrological patterns, which may not be easily available. Other approaches create user-friendly interfaces to navigate a series of pre-run results such as the Foreseer tool.

In the case of transboundary river systems, new strides are being made to develop and apply toolkits. One major recent study combines agricultural, hydrological, climate and energy modelling in order to assess the interference and climate vulnerability of each. Notable in this effort is the number of countries modelled (in excess of 40), with the modelling also covering eight major river basins in sub-Saharan Africa. This allowed not only for a resource consistent approach but also a regionally consistent analysis, yet it was delivered by a small team using open tools[80] over a relatively short period. This bodes well for making such approaches easily available.

[68] See for example: Sebastian Hermann and others (2012). Climate, land, energy and water (CLEW) interlinkages in Burkina Faso: An analysis of agricultural intensification and bioenergy production. *Natural Resources Forum*, vol. 36, pp. 245–262; Matthew D. Bartos and Mikhail V. Chester (2014). The Conservation Nexus: Valuing Interdependent Water and Energy Savings in Arizona. *Environmental Science and Technology*, vol. 48, pp. 2139–2149.

[69] Simplified hydrological attributes are often included in electricity system models, for an early review see Aoife M. Foley and others (2010). A Strategic Assessment of Electricity Systems Models. *Energy*, vol. 35, no. 12, pp. 4522–4530; and for an applied example see Marcio Giannini Pereira and others (2011). Strategies to promote renewable energy in Brazil. *Renewable & Sustainable Energy Reviews*, vol. 15, pp. 681–688.

[70] Manuel Welsch and others (2014). Adding value with CLEWS – Modelling the energy system and its interdependencies for Mauritius. *Applied Energy*, vol. 113, pp. 1434–1445.

[71] This builds on the Climate, Land, Energy and Water strategies (CLEWs) approach that allows for a variety of tools to be applied. The model features required and the key interlinkages to be investigated determine the toolkit used.

[72] UNDESA, *Global Sustainable Development Report: Sustainable Development Knowledge Platform* (United Nations Department of Economic and Social Affairs, 2013). Available from: http://sustainabledevelopment.un.org/index.php?menu=1621#tools

[73] Louise Karlberg and others (2015). Tackling complexity: Understanding the food-energy-environment nexus in Ethiopia's Lake Tana sub-basin. *Water Alternatives*, vol. 8, no. 1, pp. 710–734.

[74] Deborah M. Marsh and Deepak Sharma. (2007). Energy-water nexus: An integrated modelling approach. *International Energy Journal*, vol. 8, pp. 235–242.

[75] Ad de Roo and others (2014). Large scale hydro-economic modelling for policy support. In *EGU General Assembly Conference Abstracts*, p. 2951.

[76] Notable examples of Global Integrated Assessment Models (IAMs) include: DICE (Dynamic Integrated Climate Economy), RICE (Regional DICE), MERGE (Model for estimating the regional and global effects of greenhouse gas reductions), MESSAGE-MACRO, IMAGE (Integrated model to assess the greenhouse effect), IMAGE/TIMER (Targets IMage Energy Regional), MiniCAM (Mini Climate Assessment Model), GCAM (Global Change Assessment Model), WITCH (a World Induced Technical Change Hybrid System), DNE21 (Dynamic New Earth 21), MIND, ReMIND (Regional Model of Investments and Development),AIM/CGE (Asian Pacific Integrated Model). Jacques Després and others (2015). Modelling the impacts of variable renewable sources on the power sector: Reconsidering the typology of energy modelling tools. *Energy*, vol. 80, pp. 486–495.

[77] Alexander Smajgl and John Ward. *The Water-Food-Energy Nexus in the Mekong region. Assessing Development Strategies Considering Cross-Sectoral and Transboundary Impacts* (New York, Springer, 2013); the present assessment under the Water Convention.

[78] Sebastian Hermann and others (2012). Climate, land, energy and water (CLEW) interlinkages in Burkina Faso: An analysis of agricultural intensification and bioenergy production. *Natural Resources Forum*, vol. 36, pp. 245–262; Mark Howells and others, (2013)., Integrated analysis of climate change, land-use, energy and water strategies. Nature Climate Change, vol. 3, pp. 621-626; Jordan Macknick and others (2012). The water implications of generating electricity: water use across the United States based on different electricity pathways to 2050. *Environmental Research Letters*, vol. 7. No. 4; Sandra Sattler and others (2012). Linking electricity and water models to assess electricity choices at water relevant scales. *Environmental Research Letters*, vol. 7, no. 4.

[79] Matthew D. Bartos and Mikhail V. Chester illustrate missed opportunities from the lack of formal integration of the water and energy service infrastructure in the state of Arizona, U.S.A. See Bartos and Chester (2014) in footnote 68. Raffaello Cervigni and others. *Enhancing the Climate Resilience of Africa's Infrastructure: The Power and Water Sectors*. Overview booklet (Washington DC., World Bank, 2015).

[80] For the electricity modelling OSeMOSYS was employed.

CHAPTER 4

Major findings of the basin level assessments of the water-food-energy-ecosystems nexus

INTRODUCTION

This chapter provides an overview of findings from the assessments of the water-food-energy-ecosystems nexus in three transboundary river basins.

The three basins assessed are:

(a) the Alazani/Ganykh, a sub-basin of the Kura River Basin in the South Caucasus;

(b) the Sava, a sub-basin of the Danube River Basin in South-Eastern Europe; and

(c) the Syr Darya, sub-basin of the Aral Sea Basin in Central Asia.

The three basins are in many ways very different

A synthesis of the key features can be found in table 6. Most obviously they differ in terms of size – the Alazani/Ganykh hosts less than 1 million people in less than 12,000 km^2, while the Syr Darya hosts close to 24 million people in over 400,000 km^2. They are also different in terms of number of countries sharing them and their level of cooperation – the Alazani/Ganykh comprises only two countries and cooperation is not yet formalized, while the Sava involves a well established cooperation framework in which five of the riparian countries participate.[81] Figure 7 reproduces maps of the basins and table 6 provides basic information on the three basins.

The three basins also share some common characteristics

The three subregions (South-Eastern Europe, the Caucasus and Central Asia) include countries with economies in transition where economic development is a high priority. Those countries face similar challenges in terms of assuring the efficient management of their natural resources while ensuring sustainability, improving intersectoral coordination and integrating environmental considerations in sectoral policies.

The basins' natural resources play a key role in the economies of the riparian countries in the three basins

Their sustainable use and management is therefore essential in promoting and protecting the socioeconomic development of the riparian countries.

The varying status of transboundary cooperation across the three basins has influenced the focus of the nexus assessments

In the Alazani/Ganykh, there is some transboundary cooperation on a technical level but it has not been formalized. An agreement on the wider Kura Basin between Georgia and Azerbaijan was being negotiated at the time this report was being compiled. If the agreement is concluded within the envisaged multisectoral scope, the bilateral commission (to be established) could address some of the issues identified in the nexus assessment. In the Sava, where transboundary cooperation is well developed and the International Sava River Basin Commission (ISRBC) offers an established platform, the nexus assessment focuses on exploring how to better involve the energy and agriculture sectors in basin cooperation, including the support of quantitative modelling techniques. Finally, in the Syr Darya, the existing institutional capacity for transboundary cooperation is not being used owing to the lack of trust and understanding between the riparian countries, therefore the nexus assessment focuses on national policies and technical measures that could help to address the nexus challenges while reducing pressure on the shared resources and hence create more favourable conditions for advancing transboundary cooperation.

The findings from each nexus assessment are both context specific and process specific

They depend on the specific governance context, the current pressures on resources, and the interlinkages experienced in each basin. They also depend on the quality of the nexus assessment in each basin, as determined by the availability of information, the resources available for the assessment, and the level of participation of the key authorities and other stakeholders.

[81] Of the five riparian countries, Montenegro is an observer. The areal share of Albania is very small.

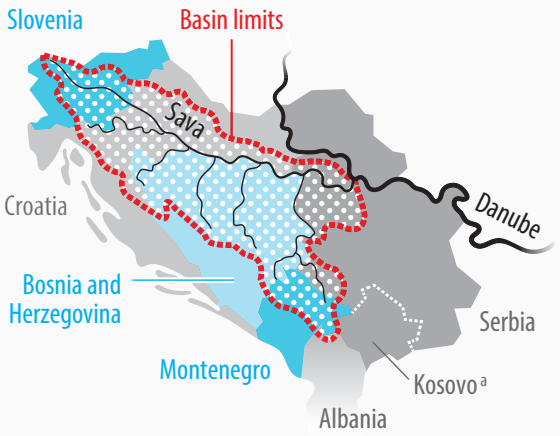
FIGURE 7
Location of assessed basins

Transboundary surface waters in the Caucasus

ALAZANI/GANYKH BASIN

Transboundary surface waters in South-Eastern Europe

SAVA BASIN



Transboundary surface waters in Central Asia

SYR DARYA BASIN

[a] United Nations administered territory under Security Council Resolution 1244 (1999).

TABLE 6
Basic information on the river basins assessed

	Alazani/Ganykh	Sava	Syr Darya
Size of the basin (square kilometres)	11,700	97,700	410,000[a]
Length of the river (kilometres)	391	945	3,019[b]
Mean flow[c] (cubic metres per second)	110	1,722	1,010
Population (inhabitants)	854,500 (2013)	8,760,000[d]	23,918,900 (2012)
Countries sharing	Azerbaijan, Georgia	Albania, Bosnia and Herzegovina, Croatia, Montenegro, Serbia and Slovenia	Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan
Climate	Warm temperate climatic zone	Warm temperate climatic zone	Arid/semi-arid climatic zone
Main water uses	Irrigated agriculture, hydropower	Hydropower and thermo-electric cooling, navigation	Irrigated agriculture, Hydropower and thermo-electric cooling
Main water management issues (non-exhaustive lists)	Erosion and sedimentation; flood management	Hydropower expansion, point source pollution (insufficiently treated wastewaters); flood management	Flow regulation (reconciling between hydropower and irrigation), diffuse and point source pollution

[a] The estimates of the basin area vary. This figure corresponds with the delineation shown in the map of the Syr Darya Basin.

[b] From the headwaters of the Naryn River.

[c] The mean discharge volumes shown are from the following locations: the Alazani/Ganykh – Agrichay gauging station, Azerbaijan, Sava – at the river's mouth, Syr Darya – Uchtepe-Kara Darya. Not all the values are from the mouth of the respective river, so they are only indicative of the magnitude. *Source:* UNECE. *Our waters: Joining hands across borders* (New York and Geneva, United Nations, 2007); UNECE. *Second Assessment of transboundary rivers, lakes and groundwater* (New York and Geneva, United Nations, 2011).

[d] Without Albania. *Source:* International Sava River Basin Commission, Sava River Basin Management Plan (2014).

THE GOVERNANCE CONTEXT

The need for transboundary management of resources in the three basins is fairly recent

All of the countries involved in the three basins (except Albania) became independent upon or after the break-up of the Soviet Union and Yugoslavia in 1991. Thus, basins that were entirely within the Soviet Union (Alazani/Ganykh and Syr Darya) or Yugoslavia (Sava) became transboundary basins overnight. This immediately complicated the management of basin resources, as the newly independent States had their own political objectives, which eventually led to tensions between the countries. However, it also meant that – compared to transboundary basins elsewhere – the riparian countries shared a tradition of management as well as similarities in terms of national governance structures, even if later developments shaped them further, occasionally evolving in different directions.

Basin level cooperation and governance varies significantly across the three basins

Water governance is well developed in the Sava where the Framework Agreement on the Sava River Basin (FASRB) has been in force since 2004 providing the legal framework for cooperation covering various water uses, with the ISRBC acting as its implementing body. Conversely, water governance is under development in the Alazani/Ganykh where there are no joint cooperation bodies yet in place; although a draft bilateral agreement between Azerbaijan and Georgia on the shared water resources of the Kura Basin is currently being negotiated. The situation in the Syr Darya is somehow in-between. There is an existing legal basis for cooperation[82] but this has gradually weakened or is being phased out as the implementation of the Agreement on the Use of Water and Energy Resources in the Syr Darya River Basin (with several joint bodies in place, including the International Fund for Saving the Aral Sea (IFAS) Board as the apex body) is exhibiting a number of efficiency and coordination challenges.

Governance of energy resources is heavily influenced by regional level development of the electricity markets

Coordinated energy management in the Sava is at an early stage, but all the countries concerned are members of the Energy Community.[83] Energy cooperation is more developed in the Syr Darya region around the Central Asia Power System (CAPS) and the Commonwealth of the Independent States (CIS) Electric Power Council, but political disagreements are impeding the functioning of a regional energy trade. In addition, water cooperation frameworks in the Central Asia region, and specifically in the Syr Darya Basin, do not include energy authorities despite the importance of hydropower in upstream countries. In the Alazani/Ganykh Basin the main feature is bilateral trade, involving the import of gas to Georgia from Azerbaijan but the subregion also forms an important corridor for oil conveyance.

[82] The existing legal basis refers notably to the Agreement on the Use of Water and Energy Resources in the Syr Darya River Basin (1998), but also the regional agreements on the Aral Sea Basin that were concluded in the early 1990s.

[83] The Treaty establishing the Energy Community was signed in Athens on 25 October 2005 between the European Community, Albania, Bulgaria, Bosnia and Herzegovina, Croatia, the former Yugoslav Republic of Macedonia, Montenegro, Romania, Serbia and the United Nations Interim Administration Mission in Kosovo pursuant to the United Nations Security Council Resolution 1244. The Energy Community process, which is mainly about investments, economic development and energy security, was initially linked to Western Balkans but after the accession of Moldova and Ukraine, the leading motivation has shifted to the transfer of the EU energy policy.

In the Syr Darya, governance failures have led to regression in cooperation over water allocation

The Syrdarya basin organization only covers the middle course of the basin and does not address hydropower. Together with the lack of trust among riparian countries, this has led to past water allocation agreements not being fully implemented and no new agreements over water allocation being reached. Bilateral cooperation specifically on the management of the Syr Darya is currently not formalized between the riparian countries, even between Kyrgyzstan and Tajikistan despite international assistance supporting negotiations. Water issues, among others, may also be raised at higher political levels on a bilateral basis.

In the Sava, there is a good governance basis for the integrated management of basin resources

Compared with institutions for transboundary cooperation in water management elsewhere, the mandate of ISRBC is thematically broad. The Strategy on Implementation of FASRB[84] includes as a specific objective stronger dialogue with stakeholders from the different sectors, as well as stronger integration of water policy with other sectoral policies. A consultation process on national and sectoral development strategies through the ISRBC, taking into account basin level impacts, would improve coordination.

Also in the Sava, there is mutual support between governance at the basin level and at the supra basin level

The Sava countries also take part in water cooperation at the level of the Danube Basin, which was formalized earlier for both navigation and protection in the form of conventions. The Sava and Danube basins are among the few river basin districts where the EU Water Framework Directive is applied and where river basin management plans are coordinated with the participation of countries that are not EU member States. The ISRBC has also played a role in the implementation of the EU strategy for the Danube region.

Current governance arrangements do not always support improvements in policy coherence

In the Alazani/Ganykh Basin, needs include policy coherence on energy access, reforestation and water management, as well as coherence between land use planning and infrastructure policies, particularly with regard to repair and maintenance (especially in Georgia). The needs in the Sava Basin include policy coherence between flood protection, erosion and sediment control, as well as between hydropower development, climate mitigation and environmental protection (more specifically to ensure good water status). The needs in the Syr Darya Basin include coordination on the optimization of reservoir operation regimes and on water quality policies, as well as between energy security, agricultural production and water quantity management.

Among the Sava River Basin countries, the EU accession and approximation provide a common driver and a factor in the integration of policies

This includes supporting investments in water management and beyond. These processes introduce a gradual level of harmonization to the legal bases. Depending on the status of each country towards the EU, compliance with the *acquis communautaire* and other relevant stipulations found in European Union law is either a matter of treaty obligation (for EU member States) or a part of the closure of particular chapters in the accession process (non-member States). In the EU neighbourhood, the influence is more subtle: in Georgia, implementing the Association Agreement with the EU (signed in June 2014) already influences legislation under development (including the new Water Code), and to enhance capacity some adjustments in the structure of the Ministry of Environment Protection, for example, were made. Azerbaijan has participated in EU Neighbourhood programmes.

[84] ISRBC, *Strategy on Implementation of the Framework Agreement on the Sava River Basin* (International Sava River Basin Commission, 2011).

TABLE 7
The legal basis and scope of cooperation in the basins assessed from the perspective of water

Aspect	Description
ALAZANI/GANYKH	
Legal basis of (water) cooperation	Agreement between the governments of Georgia and Azerbaijan on Cooperation in Environmental Protection (1997). Memorandum of Understanding between the Ministry of Ecology and Natural Resources of Azerbaijan and the Ministry of Environment Protection and Natural Resources of Georgia (2007, signed).
Level of formality of cooperation, scope, functioning	A bilateral agreement on the transboundary waters of the Kura River is being negotiated, which would provide for the establishment of a joint commission. Technical cooperation rather regular.
Scope of cooperation in terms of sectors	Technical cooperation on environmental protection (the new draft water cooperation agreement proposes a multisectoral scope, including agriculture and energy).
SAVA	
Legal basis of (water) cooperation	Framework Agreement of the Sava River Basin (2002) strengthened with: Protocol on Navigation Regime (2002) Protocol on the Prevention of Water Pollution caused by Navigation (2009, signed), Protocol on Flood Protection (2010, signed). Protocol on Sediment Management (2015, signed).
Level of formality of cooperation, scope, functioning	A multisectoral basin commission (International Sava River Basin Commission), with subsidiary bodies, meets regularly; 4 riparian countries are Parties, 1 is an observer.[a]
Scope of cooperation in terms of sectors	River basin management, navigation, hazards, sustainable river tourism.[b]
SYR DARYA	
Legal basis of (water) cooperation	Agreement on Cooperation in Joint Management of Use and Protection of Water Resources of Interstate Sources. Establishment of the Interstate Commission for Water Coordination of Central Asia (1992).[c] Agreement on Joint Actions to Address the Problems of the Aral Sea and Sub-Aral Area, Environmental Rehabilitation and Socio-Economic Development of the Aral Region (1993).[d] Agreement on the Use of Water and Energy Resources in the Syr Darya River basin (1998).
Level of formality of cooperation, scope, functioning	Basin organization (Syr Darya Basin Water Organization) in practice does not cover the whole basin at present.
Scope of cooperation in terms of sectors	Earlier water and energy at the basin level; now limited cooperation. Some Foreign Offices may discuss bilaterally water issues ad hoc.

[a] Montenegro has an observer status. Albania's share of the river basin is very small.

[b] While tourism is not explicitly mentioned in the Framework Agreement itself, in the Declaration from the Second Meeting of the Parties to the FASRB (Belgrade, 1 June 2009), the Parties encouraged the ISRBC to continue working on the development of sustainable river tourism in general, and the nautical tourism in particular. The Framework Agreement's Strategy on Implementation (Zagreb, ISRBC, 2011) elaborates on the development of nautical tourism.

[c] Turkmenistan is also a Party to this agreement.

[d] This agreement, to which Turkmenistan is also a Party, established the Interstate Council on the Problems of Aral Sea Basin (now absorbed by the International Fund for Saving the Aral Sea).

BOX 11.
Progress in Integrated Water Resources Management

Depending on their relationship to the EU, the Sava countries have adopted the preparation of river basin management plans to different degrees: the EU member States, Croatia and Slovenia, are obliged to fully implement WFD, while the others have acquired valuable experience through participation in the preparation of the first River Basin Management plan of the Sava River Basin.

The countries of the Caucasus and Central Asia had experience of river basin management in the Soviet period. The Schemes of Integrated Use and Protection of Water Resources had similar features to IWRM, but were not developed by applying a participatory process and did not properly address environmental issues. Application of the basin approach, i.e. the transition from using administrative borders to boundaries of hydrographic basins, is gradually being introduced in these subregions.

Comprehensive IWRM plans are lacking for the time being in Azerbaijan and Georgia. However, the new Water Code for Georgia, which was subject to public consultations when this report was finalized, will introduce a river basin approach and by-laws to put more integrated management of water resources into place.

Azerbaijan is also in the process of developing its national legislation to support the transition to a basin management approach. The National Water Strategy under development incorporates various aspects of water management, but has proven to be challenging to complete and adopt.

The introduction by legislative reforms of basin management in the Syr Darya riparian countries requires the creation of basin based organizations that will be able to develop river basin plans. The introduction of governing institutions at the basin level was initiated in Kazakhstan from 2005 to 2008 (River Basin inspectorates and Councils), in Uzbekistan from 2003 (Basin Irrigation System Authorities) and in Kyrgyzstan in 2008 (Talas Basin Council). In Tajikistan, the establishment of such structures is underway. At present, the river basin councils in Kazakhstan have an advisory role to the basin inspectorates.

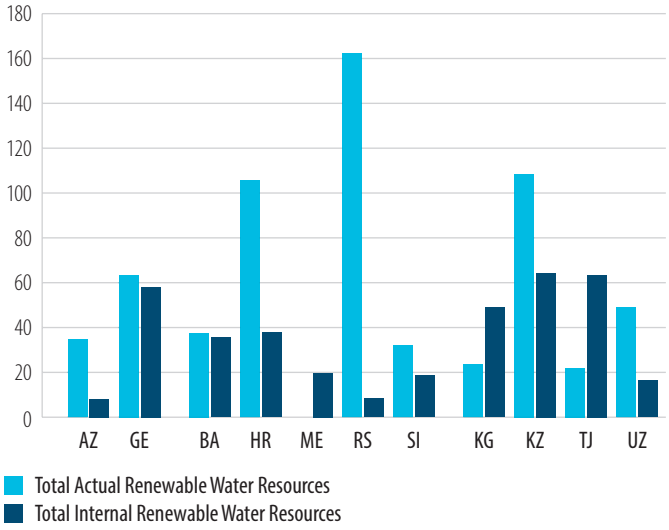
Source: UNECE and OECD. *Integrated Water Resources Management in Eastern Europe, the Caucasus and Central Asia: European Union Water Initiative National Policy Dialogues progress report 2013*. (New York and Geneva, United Nations, 2014).

DRIVERS OF PRESSURES ON BASIN RESOURCES

The development models in the three basins put different pressures on the basins' resources

There are large disparities in water resources among riparian countries in the three basins (see figure 8). The Sava and Alazani/Ganykh receive tributaries all along their course, unlike the Syr Darya. Average water flow for the Sava and Alazani/Ganykh is largest at their mouths, while for the Syr Darya the average flow is lower downstream.[85] Water management challenges differ across basins: water scarcity is a major issue in the Syr Darya but not in the Alazani/Ganykh and the Sava (see table 8). This is partly due to the hydrology of the basins and partly to the demand for water resources. Indeed, water use per unit of GDP varies significantly: it is lower in the Sava countries and higher in the Syr Darya countries (figure 9), unlike energy use per unit of GDP which has the same order of magnitude in all countries. While the agricultural sector is the major consumptive user in the Alazani/Ganykh and the Syr Darya, in the Sava that role is attributed to the energy sector.

FIGURE 8
Renewable water resources by country, shown with two different indicators (km³/year)



The difference between the values is mainly explained by the Total Renewable Water Resources (TRWR) accounting for inflows and outflows that the country has agreed with neighbours.

Sources: FAO Aquastat country reports, as of 2014. The value for Montenegro is an estimate of renewable surface water resources taken from the Environmental Performance Review of Montenegro, UNECE (2015).

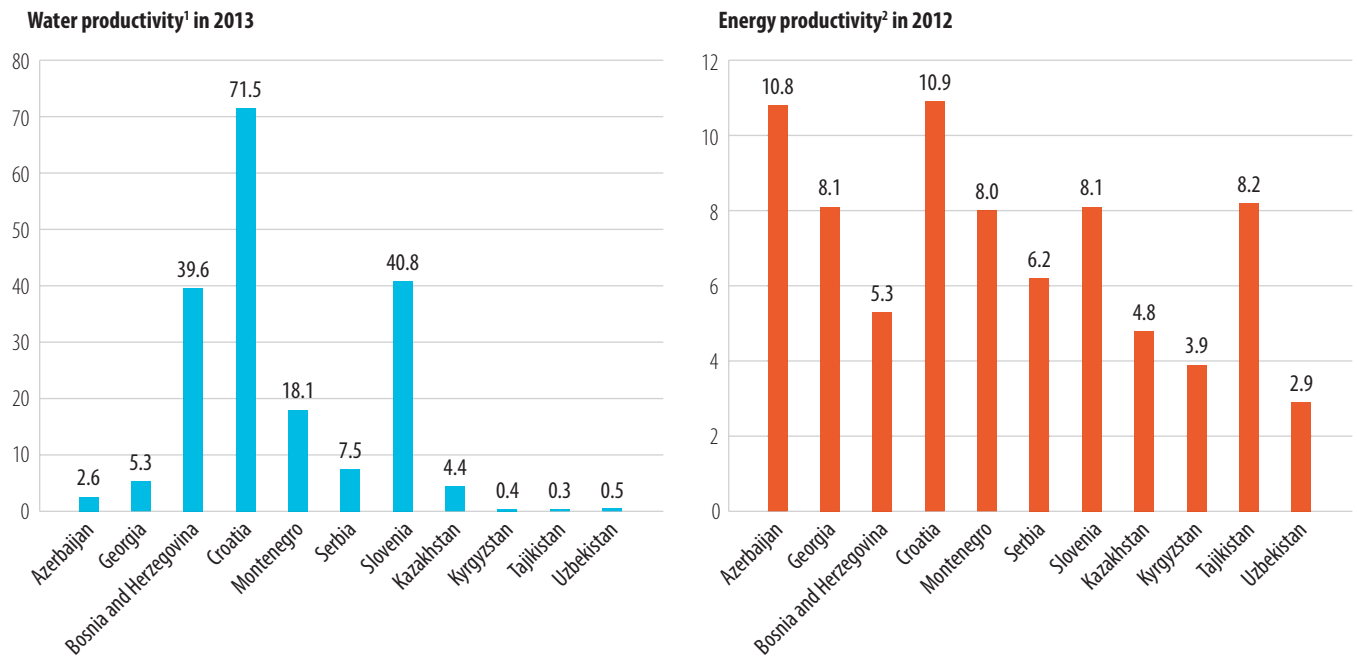
TABLE 8
Key characteristics of water resources, management infrastructure and use in the assessed basins

Aspect of the water resource or its management	Description
ALAZANI/GANYKH	
Water resource base of the countries	Georgia has large freshwater resources. Azerbaijan is more arid than Georgia and relies heavily on transboundary inflow from Georgia and other countries.
Water scarcity in the basin	Water scarcity for the time being is not an issue.
Water infrastructure in the basin	Irrigation schemes in the plain – mainly functioning with gravity flow. The Alazani/Ganykh discharges to the Mingechevir Reservoir on the Kura River. The associated dam is the largest for hydropower generation in the region. Most of the hydropower installations on the Alazani/Ganykh are small and medium-sized, run-of-the-river type (without impounding the flow).
Largest water-consumptive use	Irrigation (including high losses).
SAVA	
Water resource base of the countries	Croatia and Bosnia and Herzegovina are the richest countries in terms of internal water resources, followed by Montenegro and Slovenia, and finally Serbia. The transboundary waters of the Sava are vital for all countries.
Water scarcity in the basin	Water scarcity for the time being is not an issue, although climate change studies generally predict scarcity to increase.
Water infrastructure in the basin	Irrigation not much developed. Hydropower plants with large potential still unexploited. Infrastructure to facilitate navigation (locks, weirs etc.)
Largest water-consumptive use	Thermal and nuclear power plants.
SYR DARYA	
Water resource base of the countries	Some countries are highly dependent on external resources for water security. For example, the whole country of Uzbekistan and the south region of Kazakhstan would be in conditions of absolute scarcity without the inflow of transboundary waters.[a] Most of the Syr Darya's flow is generated in Kyrgyzstan.
Water scarcity in the basin	Water scarcity is an issue in some areas (either in absolute or relative terms).
Water infrastructure in the basin	River completely regulated. Dams, reservoirs, counter-regulators. Large hydropower plants (the largest dam, Toktogul, is located on the Naryn tributary in the upstream part of the river). Large irrigation schemes in the mid-stream and downstream. Extensive and complex (and energy consuming) pumping and drainage systems.
Largest water-consumptive use	Irrigation (including high losses).

[a] Vladimir Yasinskiy and others. *Modern Water Management in the CIS Countries*. (Eurasian Development Bank, 2014).

[85] UNECE, *Second Assessment of Transboundary Rivers, Lakes and Groundwaters* (New York and Geneva, United Nations, 2011).

FIGURE 9
Water productivity (left) and energy productivity (right) in the riparian countries of the basins assessed



[1] Water productivity is calculated as GDP at constant 2005 price level of U.S. dollars divided by annual total water withdrawal in cubic metres.

[2] Energy productivity is calculated as GDP at constant 2011 international dollars divided by energy use in oil equivalent kilograms. An international dollar has the same purchasing power over GDP as a U.S. dollar in the United States.

Agricultural development puts major pressure on the basins' resources

Agricultural uses represent 58 per cent to 84 per cent of total water withdrawals in the Alazani/Ganykh countries. Demand for agricultural water use is expected to grow following the expected increase in agricultural production (due to a combination of export-led demand and government support). In the Sava Basin, the share of water used for agriculture and for irrigation in particular is very limited, but is expected to expand. In the Syr Darya countries, agricultural uses represent 66 per cent to 93 per cent of total water withdrawals. Large irrigation schemes (and inefficient water use) have led to a severe reduction of flows reaching the Aral Sea with significant consequences for the environment as well as the livelihoods and health of local populations. Poor agricultural practices and deteriorating infrastructure have also had an impact on land and soil resources (such as salinization), while irrigated agriculture creates a high demand for power in the Syr Darya Basin during the growing season.

The economic importance and characteristics of agriculture vary across the basins

In the Sava, agriculture represents around 10 per cent of employment, and while 35 per cent of land is estimated to be agricultural, very little is irrigated. In the Alazani/Ganykh, grape production for winemaking (and the emerging tourism around wine production) is very important for the economy of the Georgian part of the basin. In the Syr Darya, where 21 per cent of land is used for crops, irrigated agriculture, including for cotton and wheat production, is a mainstay of the economy; a large part of the population depends on subsistence agriculture. Table 9 provides selected information to characterize the agricultural sector in the three basins, including its claims on land and water resources.

TABLE 9
Selected information and indicators to characterize agriculture, land resources and irrigation in the assessed basins

Basin	Alazani/Ganykh	Sava	Syr Darya
Main agricultural products / main crops	Grapes: the most economically relevant crop on the Georgian side.	In order of importance: corn and wheat production, oil plant production (soy and sunflower), orchards and vineyards.	Historically, cotton for export. Nowadays, a decrease in cotton and a parallel increase in wheat.
Organization of farming	Household farms constitute some 95% of the total in both Azerbaijan and Georgia (the remaining 5% are commercial type)[a]	More than 85% of the total agricultural area in the basin is owned by small farmers.[b]	Smallholder farming emerged after large collective farms were split. In some of the riparian countries private land ownership has been introduced.
Land use/land cover[c]	45% cropland 12% grassland/ shrubland 42% forest 1% surface with little or no vegetation 0.1% others	35% cultivated 15% grassland/shrubland 49% forest 1% others	21% cultivated 19% grassland/shrubland 57% surface with little or no vegetation 2% water bodies
Water used for irrigation (million m^3/year)	490	30	28,900
Irrigation per capita (m^3/year per person living in the basin)	574[d]	3[e]	1,209[f]

[a] Harald Leummens and Mary Matthews. Transboundary Diagnostic Analysis – update 2013. (Baku-Tbilisi-Yerevan, UNDP/GEF Project Reducing Transboundary Degradation in the Kura-Ara(k)s River Basin, 2013).

[b] Sava River Basin Management Plan. (Zagreb, International Sava River Basin Commission, 2014).

[c] For the Sava and the Syr Darya: UNECE. *Second Assessment of Transboundary Rivers, Lakes and Groundwaters* (New York and Geneva, United Nations, 2011); for the Alazani/Ganykh: calculated at the Department of Land and Water Resources Engineering, KTH, using GlobCover geo-spatial map of land use/land cover: Sophie Bontemps and others, GlobCover 2009 Products description and validation report. (Catholic University of Louvain and European Space Agency, 2011).

[d] Georgian expert data and Integrated River Basin Planning: Alazani Watershed, Technical Report for U.S. Agency for International Development, Water Management in the South Caucasus Project. (Tbilisi, Alazani Watershed Consortium, 2002).

[e] Sava River Basin Management Plan. (Zagreb, International Sava River Basin Commission, 2014).

[f] The calculation was made assuming that the irrigation equals 95 per cent of the agricultural water use (some 5 per cent is assumed to be used for livestock based on information provided by SIC-ICWC. *Source:* Data collected from national water resources authorities and aggregated by provinces within the Syr Darya River Basin, CAWATER Info database. (Tashkent, Scientific Information Centre of the Interstate Coordination Water Commission, 2013).

Energy development will also put increasing pressure on basin resources

In the Alazani/Ganykh, hydropower is being explored but the geomorphologic characteristics of the basin limit its possible development; there are also plans to exploit solar, wind and biomass, and there is also potential for geothermal sources. In the Sava, hydropower development creates concerns in some environmentally sensitive areas of the basin. In the Syr Darya Basin, upstream hydropower facilities have shifted to winter production to meet peak electricity demand in Kyrgyzstan, which has reduced water availability in the growing season for agriculture downstream, altered ecosystems in many areas along the river, and led to frequent flooding along the river in wintertime. The efficiency of electricity transmission could be improved, reducing pressures on the basin's resources. In Kyrgyzstan grid losses in recent years have reached 16–18 per cent on distribution lines and 5-6 per cent on transmission lines.[86] The basin is strategic for the development of oil and gas pipeline networks, as well as power transmission lines to connect the basin with China and South Asia.

Energy generation potential is generally asymmetric, providing opportunities for energy trading and for improving energy security

Figure 10 shows that while all Sava countries are net energy importers, the other two basins include both net energy importers and net energy exporters. For example, in the Alazani/Ganykh Basin, Azerbaijan is an important producer and exporter of fossil fuels, while Georgia is mainly rich in hydropower potential (largely untapped). Table 10 provides key characteristics of energy sources, production and cooperation frameworks in the assessed basins. A mix of energy sources across the countries sharing a basin provides complementarity. While hydropower can be used to integrate more intermittent renewable energies, it remains vulnerable to variability of flow. Good interconnectedness allows for electricity deficits and surpluses to be balanced effectively.

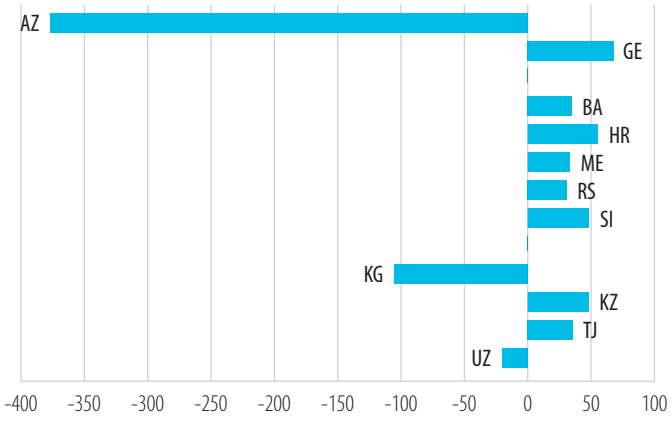
In all the basins, there is active hydropower development that may affect other water uses or the environment, but the scale is very different

In the Syr Darya Basin, large scale dams and reservoirs are operated and are still in the plans for energy development. In the Sava Basin, it is mainly small and medium scale hydropower plants that are developed. In the Alazani/Ganykh Basin, the hydropower potential is still to be assessed in more detail, though the geological conditions pose challenges to construction. Both Azerbaijan and Georgia support small hydropower production through different schemes (such as power purchase guarantees and feed-in tariffs).[87] Table 11 and figure 11 show the importance of hydropower in relation to other sources of electricity generation.

[86] Based on information from the Ministry of Energy and Industry of Kyrgyzstan.

[87] Liu, H., Masera, D. and Esser, L., eds. *World Small Hydropower Development Report* (United Nations Industrial Development Organization and International Center on Small Hydro Power, 2013).

FIGURE 10
Net energy imports as a percentage (%) of total energy use



Source: World Development Indicators. World Bank (2011)

TABLE 10
Key characteristics of energy sources, production and cooperation frameworks in the assessed basins

Aspect of the energy sector	Description
ALAZANI/GANYKH	
Energy source base of the countries	Azerbaijan is rich in fossil fuels (oil, natural gas mainly) and is a strategic supplier of natural gas to Europe. Georgia has a high hydropower potential, largely unexploited.
Energy production in the basin	Hydropower production exists and has potential to expand but there are limitations to its development where slopes are prone to mudslides[a] Other renewable sources are limited to small installations.
Energy cooperation frameworks	Fossil fuels (natural gas) export from Azerbaijan to Georgia.
SAVA	
Energy source base of the countries	Some countries are rich in fossil fuels, and others in hydropower. Coal is an important share of energy production in Serbia, Bosnia and Herzegovina and Slovenia. Nuclear is important only in Slovenia. Montenegro has a large unexploited hydropower potential.
Energy production in the basin	Energy production is a very important sector (both hydropower and thermal, and one nuclear plant) and expansion of capacity is planned in every country. Other renewable energy sources are currently underdeveloped but all countries are committed to expand their share of renewables and these will likely be produced in the basin area.
Energy cooperation frameworks	Energy Community; increasingly the EU market.
SYR DARYA	
Energy source base of the countries	Kazakhstan and Uzbekistan are rich in fossil fuels. In particular, Kazakhstan holds oil and coal reserves that are among the largest in the world – and is a leading exporter of oil – and Uzbekistan is rich in natural gas. Kyrgyzstan and Tajikistan are rich in hydropower. Exploitable coal reserves found in Kyrgyzstan and Tajikistan are limited.
Energy production in the basin	From an energy production perspective, the Syr Darya Basin is vital for Kyrgyzstan, which is also planning to expand its hydropower capacity. Thermal production is important. There is both potential and interest to develop small hydropower, upstream in particular. Significant potential for developing other renewables (e.g. wind and solar) currently unexploited.
Energy cooperation frameworks	Central Asian Power System (CAPS), the regional electricity grid, currently not fully functional; bilateral trade deals. The CIS Electric Power Council provides a platform for coordination between the countries forming the CIS Common Power Market.

[a] The actual hydropower potential is under evaluation by the Ministry of Energy of Georgia.

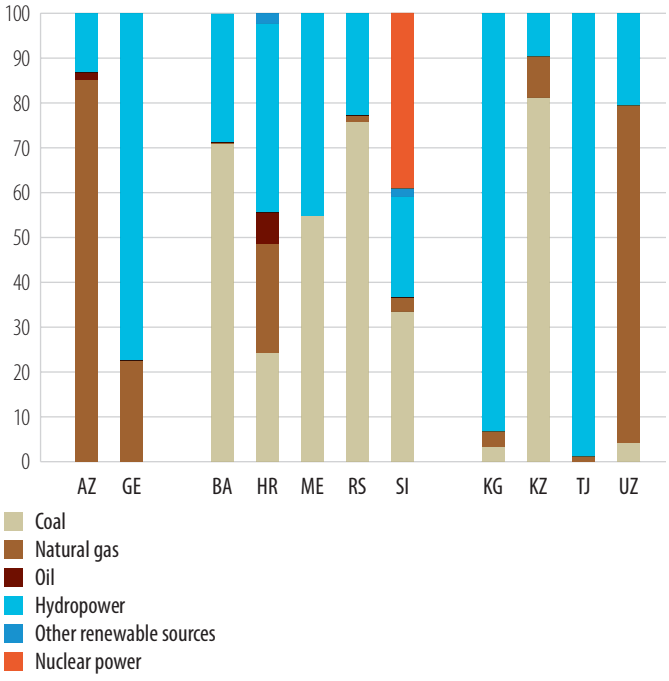
TABLE 11
Selected indicators of energy production and consumption in the basins

Basin	Alazani/Ganykh	Sava	Syr Darya
Electricity production (country level) kilowatt hours billions	AZ: 20.3 GE: 10.2	BA: 15.3 HR: 10.7 ME: 2.7 RS: 38.0 SI: 15.9	KG: 15.2 KZ: 86.6 TJ: 16.2 UZ: 52.4
Hydropower in the basin[a] (megawatts)	38 installed capacity; 117 planned.	2,188 installed capacity; 3,358 planned.	4,614 installed capacity; 2,525 planned.
Total primary Energy Consumption per capita (million BTU per person)[b] (country level)	AZ: 58 GE: 38	BA: 91 HR: 77 ME: 62 RS: 100 SI: 153	KZ: 150 KG: 44 TJ: 26 UZ: 78

[a] The data for Alazani/Ganykh come from local experts. For the Sava, there are various sources, described in detail in Lucia de Strasser and others (2015). Draft report on the water-food-energy-ecosystems-nexus in the Sava River Basin (Royal Institute of Technology, 2015). Available from: http://www.isrbc.org. For the Syr Darya, refer to ADB, *Master Plan for Central Asia* (Asian Development Bank, 2012).

[b] Information available from United States Energy Information Administration: www.eia.gov

FIGURE 11
Electricity by source (by country)



Source: World Development Indicators. World Bank.

Additional pressures are derived from settlements, industrial development and, to a lesser extent, tourism

Fortunately, an increasing number of households are being connected to the energy and water networks, but this also prompts an increase in the demand for electricity and water supply, as well as a need for wastewater treatment. The discharge of untreated wastewater has been highlighted in the three nexus assessments. In the Sava River Basin, around 43 per cent in total of the general pollution load (or around 3 million person equivalents) is not treated. In the Alazani/Ganykh and the Syr Darya basins, the wastewater collection and treatment efforts are commonly limited to larger towns, and related deficiencies are common. In some cases, it is settlements outside of the basin (such as Baku for the Alazani/Ganykh Basin) that may place pressure on a basin's resources: groundwater from the Alazani/Agrichay aquifer underlying the basin is conveyed to supply Baku. Industrial development has been identified as a pressure in the Syr Darya, including uranium and oil extraction in Kazakhstan, tailing ponds in Kyrgyzstan, manufacturing in Tajikistan, and metallurgical and chemical industries in Uzbekistan to name a few. Beyond agriculture and energy, tourism has been identified as a growing sector in both the Sava and the Alazani/Ganykh. In the Alazani/Ganykh, growing employment opportunities in the formal economy are actually expected to reduce fuelwood collection and deforestation rates. Table 12 summarizes the pressures on the environment and the impact of environmental degradation on human activities for the different basins, sector by sector.

TABLE 12
Pressures on the environment and the impact of environmental degradation on human activities by basin and by sector

Pressures	Impacts
ALAZANI/GANYKH	
Settlements	Flash floods cause damage to constructions. Lack of wastewater treatment affects water quality.
Energy	Expansion of hydropower is not possible in upper tributaries of the river because of geological conditions. However in other parts of the basin, degradation of the hydrological regime also compromises its development. Lack of affordable energy access in Georgia aggravates deforestation and exposure to erosion and consequently, indirectly flash floods risk having more serious effect.
Industry	Agro-industry (especially wine production) the most important industry in the basin. Old storage of pesticides still affecting soil quality but this problem is being contained.
Agriculture	Flash floods cause damage to irrigation schemes that frequently are in need of rehabilitation. High amounts of fertile soil are washed away in these events, increasing sediment loads in the river.
Tourism	The existing potential for tourism – especially in the wine region of Georgia - is compromised by environmental degradation and lack of appropriate infrastructure. Also because of its rich biodiversity, the potential for tourism in the basin is high.
SAVA	
Settlements	Flood episodes can be devastating, affecting cities and smaller settlements along the river. Lack of adequate wastewater treatment in many areas of the basin.
Energy	Targets for renewables and climate mitigation push the countries to develop more hydropower while there are environmental concerns regarding the construction of new dams in environmentally sensitive areas. Extreme flood events can cause damage to thermal power plants and coal mines, affecting security of fuel supply. Although is not clear how much hydropower will be affected by climate change, thermal power plants will likely be seriously affected, either because of low water availability or increased water temperature.[a]
Industry	Various types of industry, of which chemical sector and intensive livestock production are important contributors to water quality degradation.
Agriculture	Irrigation is not developed in the basin at present time and represents a minor water user. Because of this, crops are highly exposed to droughts.
Tourism	River tourism has developed favourably, and could benefit from improved environmental quality if wastewater discharges and sedimentation are controlled better. River tourism and hydropower development are not necessarily compatible.
SYR DARYA	
Settlements	Population in the basin can experience energy and/or food insecurity.
Energy	The almost complete reliance on hydropower in the upstream makes Kyrgyzstan very exposed to limited production capacity in dry years. Flow regulation optimized for power generation in winter affects the access to water for irrigation during the vegetation period. Lack of cooling water can be a limiting factor for thermal production.
Industry	Various types of industry – from extractive industry to manufacturing and construction, to petro-chemical and agro-industry – all lacking proper wastewater treatment. Commonly low efficiency in energy use.
Agriculture	Irrigated agriculture is the main consumptive water user in the basin. Extensive use of water for irrigation and large water losses will aggravate water scarcity in water scarce areas with impact on water supply to settlements and fields, in particular downstream.
Tourism	Not developed much in the basin and not seen as having high potential.

[a] ICPDR. *ICPDR Strategy on Adaptation to Climate Change* (Vienna, International Commission for the Protection of the Danube River, 2012).

Climate change will generate additional pressures in the three basins

Climate change will affect the three basins in different ways, as described in table 13. It will generally aggravate intersectoral impacts, for example, through increasing water requirements in agriculture or affecting power generation by reduced or more variable flows. In the Sava Basin, climate is predicted to get warmer and water scarcity is likely to increase. Even if changes would not necessarily be large, at specific locations in low water years or seasonally, possible implications on other uses are worth assessing. In the Alazani/Ganykh, both countries have experienced increases in temperature, and future reductions in rainfall are expected, with an estimated reduction of stream flow in the river by 9–13 per cent between 2035 and 2065.[88] In the Syr Darya, important inter-annual variations in the demand-supply water balance have already been observed and were likely influenced by changing climatic conditions. Freshwater availability in Central Asia, particularly in the large river basins, is projected to decrease due to climate change, and the melting of glaciers will slowly cause a decrease in water stocked at the source.

Climate change policies will affect the relative pressures on different resources

Each riparian country will be subject either to strict EU targets (the Sava countries depending on their commitments derived from the *acquis communautaire*) and/or targets they communicate to the United Nations Framework Convention on Climate Change (UNFCCC). Key to meeting these will be the sustainable development and use of hydropower, other renewable energy technologies, and maintaining terrestrial carbon stocks (in wetlands and forests as well as managing land-use change). Adapting to climate change is a key challenge facing all riparian countries. This may include adapting to lower levels of water availability, as well as ensuring that adequate flows of water maintain ecological systems.

TABLE 13
Climate change related projections by 2050 in the subregions where the assessed basins are located

By 2050	Caucasus (Alazani/Ganykh)	South-Eastern Europe (Sava)	Central Asia (Syr Darya)
Temperature change	+1.7°	+1.8°	+2°
Rainfall change (annual)	Not all models agree; some studies predict a decrease[a]	Seasonal changes, decrease in summer	Precipitation intensity is predicted to increase (but not all models agree on mean annual precipitation)
Runoff change (annual)	Reduction especially in late summer and early autumn, affecting tributaries of the Alazani/Ganykh[b]	Some sections of the Sava will see a decrease of mean annual discharge.[c]	Decrease by 12%
Water scarcity aggravated	Not on large scale at Alazani/Ganykh basin level[a]	Not on large scale at Sava basin level	Acute in some areas at Syr Darya basin level

Source: World Bank and GFDRR. *Disaster Risk Management and Climate Change Adaptation in Europe and Central Asia* (Washington D.C., World Bank and Global Facility for Disasters and Risk Recovery, 2009) [unless specified otherwise].

[a] ENVSEC and UNDP. *Regional Climate Change Impacts Study for the South Caucasus Region* (Tbilisi, Environment and Security Initiative and United Nations Development Programme, 2011).

[b] Medea Inashvili. Climate Change Predictions in the Alazani/Ganikh river basin, presented at the nexus assessment workshop in November 2013.

[c] ICPDR. *ICPDR Strategy on Adaptation to Climate Change* (Vienna, International Commission for the Protection of the Danube River, 2012).

The remarks on water scarcity in this table are limited to the evolution of physical availability. Even more important, especially in the shorter term, is how the different water uses will develop. For example, increased evapotranspiration owing to an increase in temperature may lead to increased water demand for irrigation.

[88] Medea Inashvili, Climate Change Predictions in the Alazani/Ganikh River Basin. Presented at the Nexus Assessment workshop in November 2013.

NEXUS LINKAGES

The dialogue with stakeholders on intersectoral issues was very broad and touched upon many aspects of the nexus in all basins

For each basin however, there is one storyline that can be selected as the most representative of current developments and intersectoral challenges. Table 14 presents the main nexus interlinkages and opportunities in each assessed basin. In addition, a number of messages emerge when looking across basins.

There are multiple energy and water linkages in the assessed basins

For example, the energy sector in the Sava Basin has proven vulnerable to the status of water resources: in dry spells generation from hydropower plants decreases, and during flooding instances cooling systems are compromised resulting in forced shutdowns. In the Syr Darya, Kyrgyzstan operates reservoirs (the Toktogul having the biggest effect) to satisfy domestic demand for energy, which peaks in winter, and thus at times limiting access to water for irrigation during the growing season. Additional examples can be found in the assessment summaries presented in later chapters.

Land and water linkages have been highlighted in the three basins, but they present specificities

In the Sava, lower impact floods (often lasting for up to four days) can be better contained if natural floodplains are complemented by spare reservoir capacity. In the Alazani/Ganykh, contaminated land from illegal and scattered open-air landfills contributes to water pollution by infiltration into groundwater or as a result of contact with river flows from the banks. In the Syr Darya, unsustainable practices in irrigation and drainage cause the degradation of soil and water, compromising the long-term usability of these resources for agriculture itself.

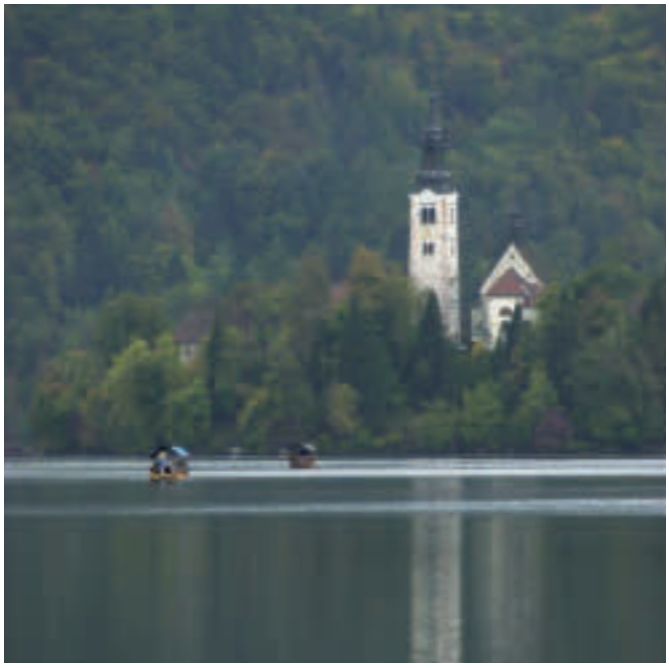
Energy and land linkages are particularly strong in the Alazani/Ganykh basin

Deforestation due to fuelwood collection in the upper Alazani leads to a decrease in the water retention capacity of land (facilitating floods), as well as an increase in soil erosion, which is exacerbated by the more frequent and intense flooding and subsequent landslides expected to be caused by climate change. Sediment and mud negatively affect the performance and useable life of hydropower infrastructure (and irrigation and other types of infrastructure), as well riverine ecosystems and hydrological functions.

TABLE 14
The main nexus interlinkages and opportunities in each assessed basin

Aspect	Description
ALAZANI/GANYKH	
Main nexus storyline	Lack of access to affordable energy aggravates deforestation, which increases the exposure to flash floods, erosion and landslides. A poor maintenance of irrigation systems aggravates the impact of flash floods on the loss of fertile soil and damage to settlements.
Key sectors	Settlements, forestry and water (hydrology and water supply for irrigation).
Main nexus interlinkages	Water-energy (hydropower), land-energy-water (biomass use, erosion/sedimentation, hydrological flow).
Main nexus opportunities	Facilitate access to modern energy sources and energy trade; minimize impacts from new hydropower development; catchment management to control erosion.
Possible solutions with multisectoral benefits	Enhanced reforestation upstream. Regular clean-up of sediments.
SAVA	
Main nexus storyline	Energy production in the riparian countries heavily depends on water availability in the Sava Basin. Targets for renewables and climate mitigation push the countries to develop more hydropower but there are environmental concerns about dam construction in environmentally sensitive areas.
Key sectors	Energy (hydropower, thermal and other renewables) and environment.
Main nexus interlinkages	Water-energy (hydropower); land-water (sediment management).
Main nexus opportunities	Expand hydropower sustainably and integrate other renewable energies; better coordinate energy planning and basin level water management between riparians.
Possible solutions with multisectoral benefits	Early warning for floods and better land use planning. Drought resilient crops.
SYR DARYA	
Main nexus storyline	Energy and food insecurity are drivers for conflicting seasonal water uses and make countries prioritize self-sufficiency over cooperation. This aggravates the current situation of sub-optimal use of resources.
Key sectors	Energy (hydropower, other renewables and trade), agriculture (irrigation schemes and trade).
Main nexus interlinkages	Water-land-ecosystems (irrigation, salinization), water-energy (hydropower), land-ecosystems.
Main nexus opportunities	Promote the restoration and vitalization of the energy market, develop the currently minimal trade in agricultural products; improve efficiency in energy generation, transmission and use; improve efficiency in water use (in agriculture in particular).
Possible solutions with multisectoral benefits	Changing/diversifying crops according to climatic conditions. Reducing dependency on dominating sources of energy.

SOLUTIONS TO ADDRESS NEXUS CHALLENGES



The nexus assessments in the three basins identified a broad range of possible solutions

Some solutions are highly specific to each basin, but there are also some common solutions. The summaries of the nexus assessments presented in chapters 5 to 7 of this report classify those solutions under five categories: institutions, information, instruments, infrastructure, and international cooperation.

Institutions

While the governance architecture is different in the three basins, they would all benefit from institutional reforms

The most common "institutional solutions" include clarifying roles and responsibilities and developing mechanisms to identify and incorporate the wider nexus impacts, as well as identifying opportunities related to multisectorality in sector based policy development. Examples of areas where roles and responsibilities need to be clarified include the management and financing of irrigation schemes, monitoring basin resources (including groundwater and water quality management), and supporting the application of sustainable development principles in economic and sectoral planning and decision-making. In some basins, institutional reforms in the nexus sectors need to be more ambitious, for example, by separating policymaking, regulation and implementation roles, or by creating decentralized institutions (such as sub-basin councils and water user associations).

Build on existing structures and mechanisms to facilitate policy integration, and extend and/or adjust them as appropriate

Potentially nexus relevant intersectoral arrangements include national climate change adaptation planning or sustainable development strategy development[89] and, for example, institutionalizing the engagement of resource-user sectors in the development of laws, strategies and plans. Other institution-related solutions include the development of institutional capacities to support better co-optimized allocation of basin resources and the development of integrated approaches to resource management, as well as resource management at the local level.

Many institutional solutions are basin specific, influenced by the current governance set-up

They include:

(a) In the Sava Basin, reviewing the mandate of the International Sava River Basin Commission to be able to discuss (and eventually act) on matters covering all relevant basin resources.

(b) In the Alazani/Ganykh, finalizing and signing the draft bilateral agreement (currently under negotiation) on cooperation for the protection and sustainable use of the water resources of the Kura-Aras river basin.

(c) In the Syr Darya, adapting the national legal frameworks to support the implementation of new technical level solutions, including motivating resource use efficiency, and improving intersectoral coordination at the basin level by increasing representation of and consultation with energy ministries notably.

Information

The implementation of a nexus approach to managing the basins' resources requires better information to improve national level intersectoral coordination and the development of a shared knowledge base for transboundary cooperation

In the three basins, the "informational solutions" most immediately identified include improving the monitoring of basin resources, data management and forecasting to ensure the resilience of energy generation and agricultural production activities. Furthermore, there was also strong demand for analysing policy implementation issues, such as barriers to the adoption of new irrigation technologies, the inclusion of nexus linkages in sectoral assessments, and mapping policy instruments and analysing their impacts. Another information related solution that was commonly highlighted was the expansion of agricultural and forestry extension programmes to support crop-shifting as well as sustainable land management practices.

Significant efforts are needed to ensure that the right information is available for policymaking and planning across sectors

In the Syr Darya, water and energy efficiency objectives could be met at lower costs if planners in each sector would consider actions in the other sectors, such as adopting water-saving technologies (drip irrigation, low-flow appliances), which would save energy used in pumping, conveying and distributing water, and in the case of households also treating and heating water. Energy efficiency could be improved by, for example, adopting more efficient thermal energy generation technologies, further promoting combined power and heat generation, and introducing or improving building standards. Notably in upgrading irrigation systems, energy and cost implications need to be carefully and site-specifically assessed. In the Sava, improved modelling would support the design of a system of multipurpose reservoirs that maximizes net benefits. At the same time, planning horizons need to be better aligned. While IWRM planning has a limited medium-term cycle and outlook, other policy areas (in particular energy) involve longer term outlooks. Integrated long-term modelling of the basin resources would help to inform national policies of long-term constraints and opportunities presented by the basins.

[89] These may or may not have led to the establishment of actual institutional structures. Kyrgyzstan has established the Coordinating Commission on Climate Change and the National Council on Sustainable Development. While effectiveness depends on the engagement of the concerned ministries and agencies, and various other factors, the coordination effort across sectors in principle is good.

Instruments

There is scope for a more systematic use of policy and economic instruments to address the trade-offs and exploit the synergies offered by a nexus approach

In addition to the information-related instruments identified in the previous section, there is demand for some new regulatory instruments, in particular, minimum environmental flows, but also transboundary EIA, SEA and land use planning, as well as economic instruments. Consultation processes to review the impacts of national and sectoral development strategies, plans, programmes and major projects on basin resources (provided for by some of these instruments) promote intersectoral coordination. Laws on EIA and SEA have been introduced at the framework level throughout the Sava Basin, but in some riparian countries implementation is not yet complete and practice could be developed further. International support is provided to Azerbaijan, Georgia and Kyrgyzstan in developing and applying SEA legislation.

Rational use of resources, water and energy (electricity and heat) in particular, as well as environmental protection, needs to be motivated with incentives and an enabling environment

Economic instruments, in particular water and energy pricing, can serve to provide behaviour-altering incentives, improve the appeal of investment in efficiency and raise funds. The financial resources thus mobilized can provide the necessary support for operation and maintenance, and for upgrading and extending infrastructure. Most of the countries sharing the basins assessed have adopted the "user pays" or "beneficiary pays" principles although to different degrees, and implementation challenges are common. While farmers pay for irrigation water, the rates are typically very low and reflect neither the cost of the service nor the scarcity of the resource. In Central Asia and the Caucasus, non-consumptive water users rarely pay fees (Tajikistan is an exception), and the water supply and sanitation tariffs are low. Energy suppliers (who extract a rent from using water resources) are usually not charged for the water they use.[90] Some countries have already implemented revised water tariffs, for example, Kazakhstan has implemented volumetric tariffs while differentiating tariffs across oblasts based on water scarcity levels. In Kyrgyzstan, the price of electricity was increased in the winter to 2014–2015, and there are indications that electricity consumption decreased by about 20 per cent.[91]

Beyond individual instruments, the nexus assessments call for coherent mixes of policy instruments

For example, in the Syr Darya a combination of energy efficiency standards, public awareness and pricing reforms would support the attainment of energy efficiency objectives, while in the Alazani/Ganykh policy mixes are called for to promote switching from fuelwood to modern fuel sources and to better manage the drinking water supply and sanitation services. In addition, in all basins there is an opportunity for stepping up the enforcement of environmental regulations.

Infrastructure

The sustainable management of basin resources will require larger investment in infrastructure, both grey and green

Investing in the modernization of built (grey) infrastructure will contribute towards the preservation and protection of the basins' resources. This includes power plants reducing water demand for cooling, energy transmission lines reducing system losses, irrigation canals increasing water efficiency, and wastewater treatment plants reducing water pollution. Investing in protecting natural (green) infrastructure, such as floodplains, wetlands and forests in the upper watersheds, may be a cost-effective and sustainable solution in many cases and worth exploring further. In the case of the Syr Darya, investments in "energy transmission infrastructure" are top of the list both to facilitate the development of a more integrated regional energy market (and energy exports to non-riparian countries) and to diversify energy sources (particularly in the upstream part of the basin).

Some of the infrastructure solutions identified in the nexus assessments are not just about investing more, but about investing better

Options include ensuring that new water reservoirs (often built with the main objective of hydropower generation) are designed to maximize the benefits of multiple uses and to coordinate infrastructure investments (such as in hydropower and other renewable energy sources). Furthermore, upgrading existing infrastructure may merit prioritization over new projects. In the three basins, not just the design but also the operation of hydropower infrastructure requires specific attention as it affects downstream flows of water (and subsequent services, such as irrigation). The composition of the fuel mix is also relevant to this end.

Infrastructure solutions are linked to all other types of solutions

For example, in the Alazani/Ganykh Basin, Azerbaijan has been investing in water-efficient technologies, but in the Georgian part there is currently unclear responsibility for the repair and maintenance of the dilapidated irrigation networks. The municipalities lost the responsibility for maintenance in the reforms, which was attributed to irrigation associations in the late 1990s. However, when the associations ceased to exist in the mid-2000s it left a void when the state companies' responsibilities did not extend to such a local level of operation. In the Syr Darya Basin, Kazakhstan gradually increased electricity prices to encourage investment in the power sector, while Tajikistan's National Development Strategy envisages energy policy measures aimed at increasing electricity tariffs.

[90] ECE and OECD, *Integrated Water Resources Management in Eastern Europe, the Caucasus and Central Asia: European Union Water Initiative National Policy Dialogues progress report 2013*. (New York and Geneva, United Nations, 2014).

[91] Information available from: http://www.24.kg/ekonomika/16644/

International coordination and cooperation

While many beneficial actions can be taken at the national level, international coordination and cooperation at basin and regional level offers additional opportunities to "manage the nexus"

In the three basins assessed, there is scope to improve the legal basis for cooperation and to clarify the roles and responsibilities of basin institutions (as well as to develop their capacities). Indeed, most of the solutions identified are related to knowledge management and planning processes. One solution – not limited to but particularly relevant to the Syr Darya Basin – is the development of regional energy and food markets to optimize resource use such as cultivating crops where the conditions are most favourable, balancing energy supply etc.

Improving basin-wide monitoring, data verification and exchange, and knowledge-sharing are often the first solutions identified

They include joint monitoring (e.g. water flows and quality), joint forecasting (e.g. energy demand), as well as the identification of good practices at local and national level (for example in the area of economic valuation of ecosystem services, where Georgia has developed experience). One solution highlighted in the Sava Basin was the development of guidelines following existing examples in the Danube or the Sava relating to inland navigation, environmental protection, hydropower development and ecotourism.

But stakeholders are more ambitious and would like to see stronger planning processes

In the Sava Basin, current or planned processes offer interesting opportunities, such as the Sava River Basin Management Plan, to coordinate action between water, energy and agricultural sectors, and the Flood Risk Management Plan of the Sava River Basin to coordinate action around flood retention areas and wetlands. In the Alazani/Ganykh, the identified solutions include coordinating measures in the areas of climate change adaptation, flood risk management and water quality protection, as well as strategic planning for developing hydropower potential incorporating a nexus approach for optimizing hydropower expansion and location taking into account the cumulative effects of multiple hydropower plants.

Promoting and improving energy trade is highly beneficial, turning an asymmetry of different energy mixes into a mutually beneficial complementarity

The countries with higher reserves of fossil fuels have – up to the present time – enjoyed a higher level of energy security and, in some cases, stronger economic growth but now face the important challenges of reducing emissions and advancing sustainable development. Trade not only helps ensure the security of supply and boost economic growth it also facilitates the gradual introduction of renewable energies (other than hydropower) into the energy mix of each of the countries. Wind and solar power are by nature intermittent, and benefitting from them requires that the energy system has the necessary elements for the integration of renewables and includes more stable sources of energy. Even hydropower generation is subject to the variability of river flows. In the Syr Darya Basin, opportunities related to energy and trade cooperation, offering a wider range of benefits, could potentially allow for a more constructive path from the current "zero-sum" view on water allocation. Gas is imported from Azerbaijan to Georgia, thus improving the availability of a modern fuel alternative to biomass, at least in bigger settlements. Among the Sava Basin countries, the Energy Community and the European Union's *acquis communautaire* are gradually harmonizing regulation and making the energy market increasingly integrated. In the Syr Darya Basin, well-connected electricity grids benefit both exporters and importers, if political differences permit making use of them.

THE BENEFITS OF ADOPTING A NEXUS APPROACH

By adopting a nexus approach to the management of the Syr Darya basin's resources, riparian countries could exploit many potential benefits. The results of a rapid scoping of those benefits in each of the basins assessed are summarized in the respective basin assessments as tables of benefits (tables 15, 16 and 18). The tables follow the analytical framework for analyzing the benefits of transboundary water cooperation of the Policy Guidance Note on the Benefits of Transboundary Water Cooperation: Identification, Assessment and Communication.[92]

Adopting a nexus approach to managing water, energy and land resources, as well as ecosystem services, would capitalize on the potential benefits provided by each basin's resources and increase efficiency in resource use and overall sustainability. For example, it would improve resource security building on the complementarity of the resource bases, as well as develop resource intensive economic activities where the conditions are favourable.

Even at the transboundary level, all the benefits of adopting a nexus approach to the management of basin resources are ultimately enjoyed by individual countries. In some cases, the benefits are only enjoyed by the country that takes action. In many cases however, the actions of one country generate benefits in other countries (transboundary dimension). When potential individual solutions are evaluated ex-ante, it may be possible to identify and to some extent assess which benefits are enjoyed nationally and which ones are enjoyed by other countries. By looking at each potential measure individually, many measures may not be approved because the benefits may not justify the costs for one of the parties. However, if a number of potential individual solutions are evaluated ex-ante by each party as a package (that is, considering the aggregated benefits of the package as a whole) it is likely that a larger number of individual potential measures would be approved.

The nexus approach, which involves looking at the implications of measures from different sectors, can help define a broader "benefit cluster", thereby facilitating the widening of the scope of cooperation.

[92] UNECE, *Counting Our Gains: Policy Guidance Note on Identifying, Assessing and Communicating the Benefits of Transboundary Water Cooperation* (New York and Geneva, United Nations, 2015).

CHAPTER 5

Summary of the assessment of the water-food-energy-ecosystems nexus in the Alazani/Ganykh River Basin

INTRODUCTION

AIM, OBJECTIVES AND SCOPE

The nexus assessment of the Alazani/Ganykh Basin aims to support transboundary cooperation between Georgia and Azerbaijan in the areas of water, energy, food and environmental policies by strengthening the knowledge base for integrated policy development and decision-making.

The specific objectives of this nexus assessment are:

(a) to describe the governance context;

(b) to identify key drivers of pressure on the basin's resources;

(c) to identify and analyse key intersectoral issues;

(d) to explore the potential solutions to increase the benefits provided by the management of the basins resources that could be achieved through more coordinated policies and actions, and through transboundary cooperation; and

(e) to identify the benefits that the adoption of a nexus approach can potentially deliver.

The scope of this nexus assessment is limited to testing the nexus assessment methodology developed within the framework of the Water Convention, and to providing a scoping level assessment of the relevant issues and some possible synergetic actions (or nexus solutions) in response. This preliminary analysis (largely qualitative) could serve as the basis for more detailed analyses focusing on some of the specific intersectoral issues identified.

ASSESSMENT PROCESS

The nexus assessment in the Alazani/Ganykh Basin was carried out at the request of the governments of Georgia and Azerbaijan.

The Alazani/Ganykh nexus assessment made use of a multi-stakeholder approach involving Georgian and Azerbaijani representatives of relevant economic sectors (notably agriculture and energy), water and environment administrations, state companies or utilities and civil society.

Information for the pilot nexus assessment of the Alazani/Ganykh Basin was gathered through: (i) a basin-wide multi-stakeholder workshop that took place in Kachreti (Georgia) from 25 to 27 November 2013; (ii) two questionnaires, one factual and one perception-based (both distributed at the workshop); (iii) a desk-review of information from national strategic or policy documents, as well as documentation from relevant studies and projects, notably those prepared as part of the United Nations Development Programme (UNDP) Global Environment Facility (GEF) funded project "Reducing Transboundary Degradation in the Kura Ara(k)s River Basin" (UNDP/GEF Kura project); and (iv) information referred to by the workshop participants.

BASIN OVERVIEW

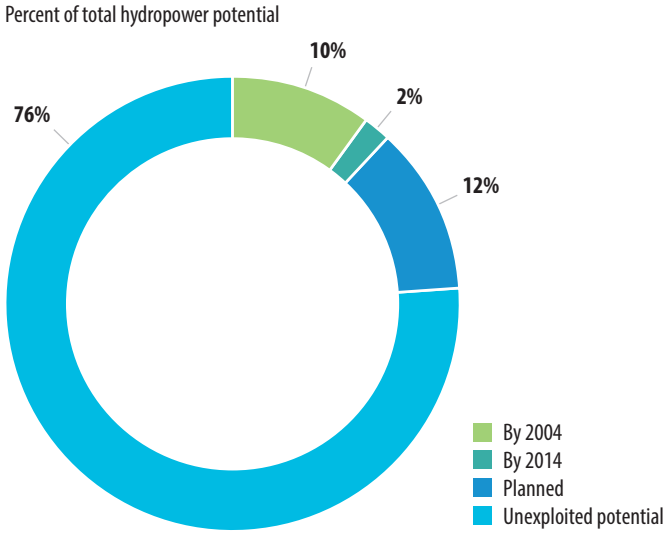
Location and extension. The Alazani/Ganykh Basin is a sub-basin of the Kura Basin. The Alazani/Ganykh River, shared by Georgia and Azerbaijan, has its sources in the Great Caucasus Mountains in Georgia and flows south-east along the Alazani plain (an inter-mountainous depression) to Azerbaijan and discharges in the Mingechevir Reservoir. The Alazani/Ganykh Basin extends over an area of 11,717 km^2, with 59 per cent of the basin being in the territory of Georgia and 41 per cent in Azerbaijan. The river – known as Alazani in Georgia and Ganykh in Azerbaijan – has a total length of 391 km of which 282 km forms the border between Georgia and Azerbaijan.[93]

Landscape and climate. The upper basin is characterized by an alpine landscape with an elevation of 2,600–2,800 m a.s.l. The floodplain landscape surrounding the meandering river in the lower basin consists of agricultural land, broadleaved dominated forest as well as steppe, bush and semi-desert.[94] The basin is located in a transition area between a dry subtropical and continental climate. It is relatively dry – precipitation ranges from 300–500 mm in the Georgian part to 440–1,240 mm in the Azeri part.[95] The annual average temperature ranges from 9 to 14°C with temperatures seldom going below -20°C or above 40°C.

Water resources. The basin has abundant water resources[96] and their overall quality is good.[97] The Alazani/Ganykh River has an average discharge of around 110 m^3/s where it empties into the Mingechevir reservoir. The Alazan/Agrichay aquifer (a confined artesian transboundary aquifer covering the majority of the basin) is the largest groundwater resource in South Caucasus. Groundwater from the Alazan/Agrichay aquifer is used to supply irrigation schemes (80–85 per cent), drinking water networks (10–15 per cent) and industry (3–5 per cent).[98] The water stored in the Mingechevir reservoir on the Kura River, into which the Alazani/Ganykh flows, is used to irrigate about 1 million hectares[99] and to fuel a 418 MW hydropower plant that constitutes 39 per cent of total installed hydropower capacity in Azerbaijan.[100]

Resource-based economic activities. Agriculture plays an important role in the basin's economy: agricultural land accounts for 47 per cent of the total land of the basin. In the Georgian region of Kakheti, which accounts for 38 per cent of Georgia's arable land and 65–70 per cent of Georgia's vineyards, the agricultural sector employs 82 per cent of the labour force.[101] In Azerbaijan, the Sheki-Zaqatala region relies on the basin's resources for the production of mineral water and soft drinks, fruits, vegetables, nuts, tobacco, dairy products and furniture.[102] The basin's morphology provides opportunities for hydropower production: small and medium hydropower plants on both sides of the basin have a combined total capacity of 38 MW,[103] while a large potential of over 700 MW remains to be exploited[104] (Figure 12). The basin also attracts tourism thanks to its natural beauty (the Kakheti region in Georgia is famous for its protected areas) and for the popularity of its local food products and wine. Figure 13 illustrates the distribution of human activities in the basin.

FIGURE 12
Installed and planned hydropower capacity



[93] Estimates of the basins dimensions vary: According to information provided by Azerbaijan, the total area of the basin is 12,080 km^2 and the river length is 413 km.

[94] AWC, Integrated River Basin Planning: Alazani Watershed, Technical Report for U.S. Agency for International Development, Water Management in the South Caucasus Project. (Tbilisi, Alazani Watershed Consortium, 2002).

[95] AWC, Integrated River Basin Planning: Alazani Watershed, as in the previous note; Information provided by the Ministry of Ecology and Natural Resources of Azerbaijan.

[96] AWC, Integrated River Basin Planning: Alazani Watershed, as in note 94.

[97] Peter Roncak and Anatoly Pichugin. Summary Report of the Joint Field Surveys in the pilot river basins. Trans-Boundary River Management for the Kura River basin Phase III – Armenia, Georgia, Azerbaijan. (EPTISA Servicios de Ingenieria S.L., 2013)

[98] UNECE, *Second Assessment of Transboundary Rivers, Lakes and Groundwaters*. (New York and Geneva, United Nations, 2011).

[99] Power plants around the world. A database of hydroelectric plants in the CIS – other countries]. Available from: http://www.industcards.com/hydro-cis.htm

[100] AzerEnerji, 2013. Energy production, power plants. Available from: http://www.azerenerji.gov.az/

[101] Ministry of Regional Development and Infrastructure, Georgia. *Kakheti Regional Development Strategy*. (Tbilisi, 2013).

[102] Information provided by Azerbaijani authorities, 2015.

[103] Ministry of Energy of Georgia, 2014. Potential hydropower sites in Georgia. Available from: http://hpp.minenergy.gov.ge/; UNIDO, 2013. *World Small Hydropower Development Report*. Available from: www.smallhydroworld.org; Grigol Lazriev and Marita Arabidze. Baseline Emission Factor for the Electricity System of Georgia. (Tbilisi, Ministry of Environment and Natural Resources Protection of Georgia, 2008). Available from: http://moe.gov.ge/files/Klimatis%20Cvlileba/Grid_Emission_Factor_Georgia.pdf; ESCO, 2014. Electricity Market Operator. Available from: www.esco.ge/index.php?article_id=18&clang=1

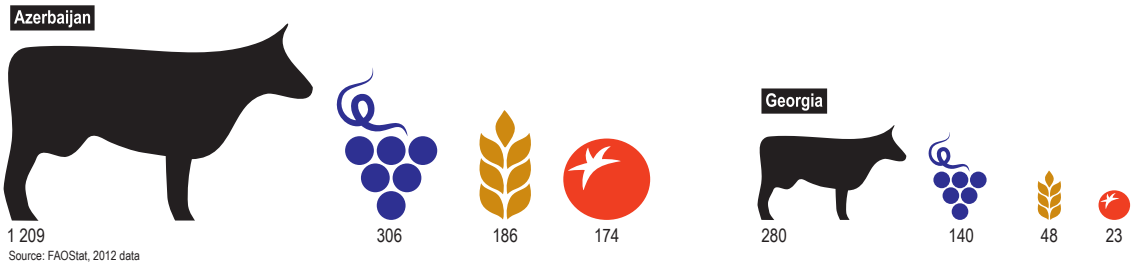
[104] Platts, 2012. World Electric Power Plants Database. Available from: www.platts.com/products/worldelectricpowerplantsdatabase.

FIGURE 13
THE ALAZANI/GANYKH BASIN

Distribution of settlements, agricultural areas, and existing and planned hydropower stations in and around the Alazani/Ganykh Basin.
Key national agricultural production statistics are presented in the lower part of the figure.

Top agricultural commodities (in million US$)

Dairy and meat | Fruits and nuts | Grains, potatoes | Vegetables



Source: FAOStat, 2012 data

Hydropower facilities

Installed capacity (MW)

<2 MW | 2 - 5 MW | 5-10 MW | >10 MW

Existing hydropower plant
Projected hydropower plant

Landcover

Forest
Agriculture
Irrigated agriculture

Other issues

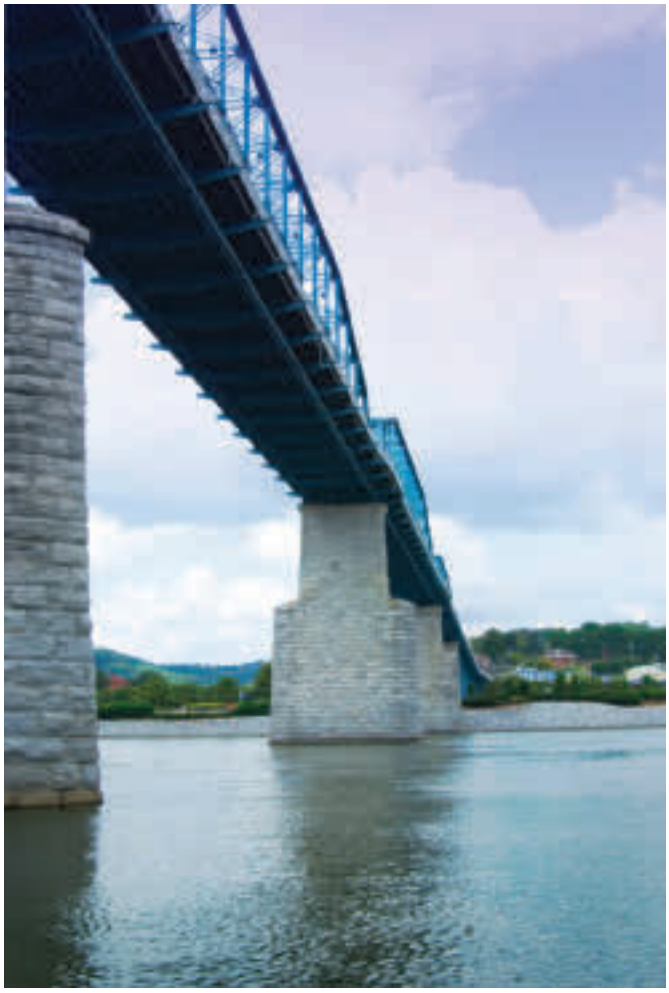
Inadequate wastewater treatment in urban areas

Population of major cities and municipalities

More than 50 000 inhabitants
20 000 – 50 000 inhabitants
10 000 – 20 000 inhabitants
Less than 10 000 inhabitants

Sources: Sources: FAOStat, 2012 data; Map "Energy sector of Georgia", USAID, 2013; GlobCover 2009, European Space Agency (http://ionia1.esrin.esa.int); Rapid Assessment of the Rioni and Alazani-Iori River Basins of Georgia, Mariam Shotadze & Eliso Barnovi, USAID, 2011, Technical Assistance for Promoting Small Hydropower in Azerbaijan, UNDP and Ministry of Industry and Energy of Azerbaijan

DESCRIBING THE GOVERNANCE CONTEXT



Basin level governance

Governance of water resources. There have been several attempts in the framework of international projects to establish basin-wide cooperation on the Kura River. So far these initiatives have not been successful. Azerbaijan seeks to promote transboundary cooperation through joint projects (Verdiyev, 2012).[105] With the support of the Organization for Security and Co-operation in Europe (OSCE) and UNECE, a draft bilateral agreement between Azerbaijan and Georgia on the shared water resources of the Kura River Basin is currently being negotiated. The agreement is foreseen to cover different water uses, as well as the protection of water resources, the restoration of ecosystems and the management of the effects of hydrological extremes, and to include a multisector representation of authorities in the planned joint commission. In the framework of GEF funded projects the development of bilateral cooperation has also been supported.

Governance of other resources. International cooperation between Georgia and Azerbaijan is generally good. The two countries have participated in a number of joint projects, for example, on monitoring and assessment, and regional meetings. Environmental cooperation agreements were signed in 1997 and 2007 (the overview of the legal basis and scope of cooperation in table 7 in chapter 4 can be referred to for more information) although they lack implementation mechanisms. Energy cooperation agreements of 1997 and 1998 have made possible electricity trading, and this cooperation is regulated by the Intergovernmental Commission for Economic Cooperation;[106] natural gas is imported from Azerbaijan to Georgia.

Cross-sectoral governance at basin level. Intersectoral cooperation has been supported as part of the UNDP/GEF Kura-Ara(k)s project covering the broader Kura Basin, which delivered an extensive Transboundary Diagnostic Analysis[107] and a Strategic Action Programme.

National level governance

Legal and institutional frameworks. The institutional frameworks for managing the basin's resources are presented in figure 14. Multiple ministries are involved: six in Georgia and six in Azerbaijan. There is in general a high degree of control by central State institutions, although in Azerbaijan national policies are implemented by state owned enterprises to a higher degree than in Georgia. The multiplicity of agencies involved in the regulation of similar resources sometimes creates overlaps and coordination challenges. Both the Ministry of Environment and Natural Resources Protection and the Ministry of Energy hold responsibilities in implementing Environmental Impact Assessments (EIA) and granting of permits regarding hydropower in Georgia requires the coordination of efforts. In Georgia the 1997 Water Law is in the process of being updated; a new Water Law incorporating the basin principle is expected to be adopted in Georgia by the end of 2015. In Azerbaijan, preparation of the National Water Strategy has been ongoing since 2012, but final agreement has not been reached between the different stakeholders at the time of writing this report.

Cross-sectoral governance. In Georgia, since 2013 the Economic Council coordinates economic policy and strategy, and the Government Commission on EU Integration coordinates sector ministries activities focused on EU Integration. Policy integration and coherence and intra-government coordination are part of the mandate of the Ministry of Economy and Sustainable Development, which also has an important role in spatial planning and EIA, and in industrial safety control.

Multi-level governance. Since 2005 the Georgian municipalities are responsible for land use planning, forests and water resources management, the provision of water supply and sanitation services, and the development of the local land reclamation system. They are responsible for supervising measures for the rational use and protection of resources and must apply Georgian legislation. Strongly delegating competences to municipalities is materialized in the granting of property rights with regard to local forests and local water resources. Irrigation associations briefly took over the responsibility for the maintenance of local irrigation systems from municipalities but when they ceased to operate the continuation of responsibility became unclear. In Azerbaijan, user associations are responsible for on-farm irrigation, water distribution and management, forming a link to the private sector. Major investments for water supply, sanitation and irrigation infrastructure in Azerbaijan are carried out by centralized state-owned joint stock companies. It is interesting to note that the Alazani/Ganykh Basin is covered by eleven administrative districts in Georgia and four in Azerbaijan.

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[105] Rafig Verdiyev, 2012. *National Water Strategy of Azerbaijan Republic*. Presentation at the NPD Core Group on the occasion of the sixteenth meeting of the EU Water Initiative Eastern Europe, Caucasus and Central Asia Working Group (Geneva, 2 July 2012).

[106] Information provided by Azerbaijani authorities, (2015).

[107] Harald J.L Leummens and Mary M. Matthews. *Updated Transboundary Diagnostic Analysis for the Kura Ara(k)s river basin*. "Reducing transboundary degradation in the Kura Ara(k)s river basin" (Tbilisi-Baku-Yerevan, UNDP/GEF, 2013)

FIGURE 14
Overview of institutions relevant to managing the resources in the Alazani/Ganykh Basin

Bilateral/subregional level	Intergovernmental Commission for Economic Cooperation	
	AZERBAIJAN	GEORGIA
Central Government	Ministry of Agriculture	Ministry of Agriculture
	Ministry of Ecology and Natural Resources	Ministry of Energy
	Ministry of Economy and Industry	Ministry of Environment and Natural Resources Protection
	Ministry of Emergency Situations	Ministry of Labour, Health and Social Affairs
	Ministry of Energy	Ministry of Economy and Sustainable Development
	Ministry of Health	Ministry of Regional Development and Infrastructure
State agencies and enterprises	State Agency on Alternative and Renewable Energy Sources	United Melioration Systems Company of Georgia Ltd
	Azersu Joint Stock Company	United Water Supply Company of Georgia
	Land Reclamation and Water Management OJSC	
	State Committee on Property Issues	
	State Water Resources Agency	
	Tariff Council	
Intersectoral state bodies		Economic Council
		Government Commission on EU Integration
		National Energy and Water Supply Regulatory Commission
Local level	Districts, municipalities	Municipalities
	Water user associations	

Supra-basin governance

European Union. Both countries are pursuing closer economic ties with the EU and are moving towards harmonization with EU legislation. Development assistance projects have familiarized the authorities with the EU Directives, including the EU Water Framework Directive. The Association Agreement between Georgia and the EU (signed in July 2014) foresees Georgia's approximation of its legislation to EU norms including environment, water, agriculture and energy related legislation. Azerbaijan is similarly strengthening cooperation with the EU and moving towards convergence with EU standards in developing national water legislation and regulations. Processes of National Policy Dialogue under the EU Water Initiative (EUWI) are ongoing in both countries to help coordinate the establishment of coherent national water resource strategies.

IDENTIFYING DRIVERS OF PRESSURES ON BASIN RESOURCES

Economic development. Economic development in the basin will depend largely on two sectors: agriculture and hydropower production. Apart from agro-industry, industry is not expected to be a significant part of the development in Georgia's part of the basin. However, Azerbaijan envisages the expansion of industry, especially strengthening the industrial infrastructure in each region.[108] Tourism is expected to increase as a consequence of the regions' natural beauty accompanied with new investments in infrastructure and the training of local service providers and authorities.[109] Growing employment opportunities in the formal economy are expected to reduce fuelwood collection and deforestation rates; since 2003 about 24,861 ha of forest have been lost on the Georgian side of the basin due to forest logging, equivalent to 8.1 per cent of forest cover.

Agricultural development. Agricultural use represents 58 per cent and 76 per cent of total water withdrawals in Georgia and Azerbaijan respectively. Demand for agricultural water use is expected to grow following the expected increase in agricultural production, including crops, livestock and aquaculture. Agricultural production is expected to increase owing to a combination of export-led demand as well as government support through a mix of subsidies, access to credit, infrastructure for irrigation, soil management, and research.[110] On the Georgian side of the basin the United Amelioration Systems Company of Georgia will increase agricultural land (up to 141,000 ha) with the rehabilitation of irrigation schemes currently underway. Restoration of existing small reservoirs and the construction of new type reservoirs on the rivers Ilto, Stori and Kabala is also planned.

Energy development. Even if the basin has secure access to electricity, alternative sources, in particular hydropower, are being explored for export e.g. through the "Energy Bridge Azerbaijan-Georgia-Turkey" project. In Azerbaijan, there are plans to exploit solar, wind, biomass and hydropower in the Balakan (1.44 MW), Zagatala (1.34 MW), Gakh and Samukh areas of the basin.[111] Georgia aims to decrease its dependency on fossil fuels by promoting renewable energies,[112] for example, one of the Kakheti region's goals is to explore the potential for investing in biofuels.[113] There is also potential for geothermal sources.[114] The main directions for the development of alternative and renewable energy sources are described in the draft strategy "On the design of public policies on the use of alternative and renewable energy sources in the Republic of Azerbaijan for 2012-2020", developed by the State Agency on Alternative and Renewable Energy Sources, and in the draft Energy Policy submitted to the Parliament of Georgia for adoption. The Georgian Ministry of Energy is refining the estimates of hydropower potential, including in the Alazani/Ganykh Basin. Azerbaijan supports small hydropower production (0.5 to 10 MW) through power purchase guarantees. Georgia supports renewable plants with less than 13 MW of generation capacity (including small hydropower) through long-term purchasing agreements, feed-in tariffs and licence-free electricity generation.[115] New investments in hydropower plants aim to benefit from carbon finance schemes, such as the Clean Development Mechanism credits.[116] It should be mentioned that hydropower development on the Georgian side of the basin is very difficult owing to the large width of the riverbed and its small slopes. Hydropower plants with small capacity can only be sited on left tributaries of the Alazani/Ganykh River – the major part of which are torrential. In addition, geological instability poses challenges and the construction and operation of hydropower plants on these rivers incurs certain risks.

Household consumption. More households are being connected to the energy and water networks prompting an increase in the demand for electricity and water, as well as the need for wastewater treatment. In addition, economic development is likely to modify consumption patterns towards higher per capita use of resources by those households already connected to energy and water networks. On the Georgian side 9.3 million m^3 of untreated wastewater were discharged in 2013.[117] In Azerbaijan, the construction of wastewater treatment plants is planned (Kahn, 7,000 m^3/day), ongoing (Shaki, 20,000 m^3/day) or completed (Zakatala district, 10,000 m^3/day).[118]

Climate change. Both countries have experienced increases in temperature and future reductions in rainfall are expected.[119] It is very likely that this will reduce stream flow in the river by 9–13 per cent between 2035 and 2065, particularly in late summer and early autumn.[120]

Other claims on basin resources. Investments have been made to transport groundwater from the Alazan-Agrichay aquifer to supply Baku, the capital,[121] such as the 213 km long Oguz-Gabala-Baku water pipeline, which can deliver 5 m^3/s.[122]

[108] The directions are elaborated on in the "State program on development of industry in the Republic of Azerbaijan in 2015-2020", adopted by order of the President on 26 December 2014.

[109] Ministry of Regional Development and Infrastructure, Georgia. *Kakheti Regional Development Strategy*. (Tbilisi, 2013); Presidency of Azerbaijan, 2014. "Azerbaijan 2020: Look into the Future" Concept for Development. Available from: www.president.az/files/future_en.pdf

[110] World Bank. *Azerbaijan Partnership Program Snapshot* (Washington D.C. World Bank, 2013).

[111] Information provided by Azerbaijani authorities (2015).

[112] Utilization of renewable energy resources and diversification of supply sources, for example, are included among the main directions for the energy sector in Georgia in the new strategic Energy Policy framework elaborated by the Ministry of Energy of Georgia, outlining the priorities and development opportunities.

[113] Ministry of Regional Development and Infrastructure, Georgia. *Kakheti Regional Development Strategy*. (Tbilisi, 2013)

[114] Energy Charter, 2012. *In depth Review of Energy Efficiency Policies and Programmes of Georgia*, (Brussels, Energy Charter Secretariat, 2012). Available from: http://www.energycharter.org/what-we-do/energy-efficiency/energy-efficiency-country-reviews/

[115] UNIDO. *World Small Hydropower Development Report*. (Vienna, United Nations Industrial Development Organization, 2013). Available from: www.smallhydroworld.org

[116] Energy Charter, 2012. *In-depth Review of Energy Efficiency Policies and Programmes of Georgia*. (Brussels, Energy Charter Secretariat, 2012).

[117] United Water Supply Company of Georgia. Information about the water supply in Kakheti, Georgia [Interview] (February 2014).

[118] Information provided by Azerbaijani authorities (2015).

[119] Michael Westphal and others. *Regional Climate Change Impacts Study for the South Caucasus Region* (Tbilisi, UNDP, 2011).

[120] Medea Inashvili. Climate Change Predictions in the Alazani/Ganikh River Basin, presented at the nexus assessment workshop in November 2013.

[121] Information provided by the Ministry of Natural Resources of Azerbaijan (2013).

[122] Information provided by Azerbaijani authorities (2015).

FIGURE 15
Key indicators describing the resources and socioeconomics of the Alazani/Ganykh riparian countries

ALAZANI/GANYKH BASIN

River length	River basin area	Basin water resource
391 km	**11,717 km²**	**7,100 million m³ /year**

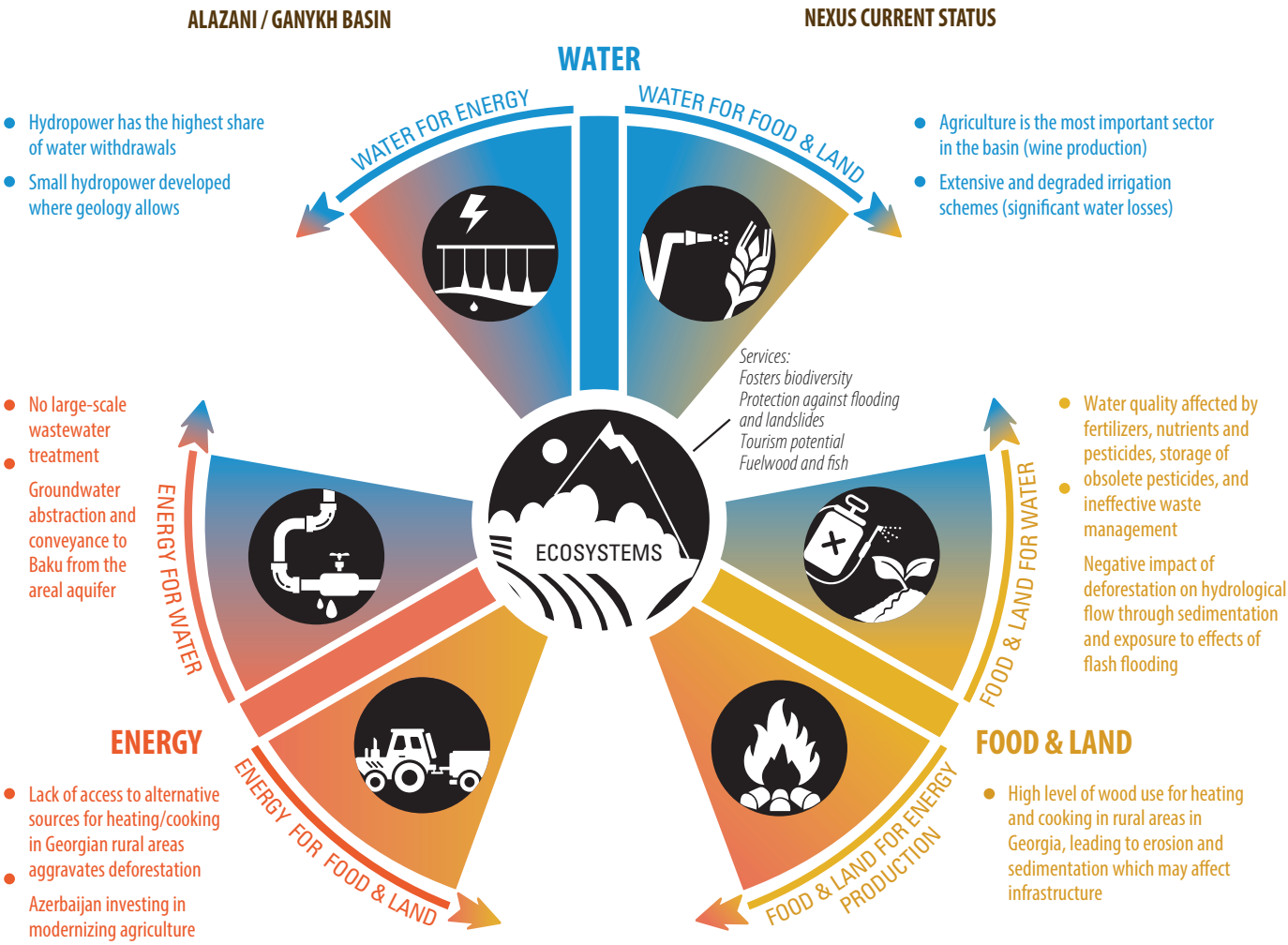
GEORGIA	AZERBAIJAN
TOTAL RENEWABLE FRESHWATER RESOURCES	
63,330 million m³ / year of which, water withdrawal: 1,823 million m³ Agriculture 58.2% Industry 22.1% Municipal 19.8%	34,680 million m³ / year of which, water withdrawal: 11,970 million m³ Agriculture 84,4 % Industry 12.8 % (est.) Municipal 2.8 % (est.)
3,600 million m³	Alazani/Ganykh basin share: 3,500 million m³
INSTALLED ELECTRICITY GENERATING CAPACITY & HYDROPOWER	
4.3 million kW of which, hydropower: 2.6 million kW Hydropower 61 % Fossil fuel 39 %	7.1 million kW of which, hydropower: 1.1 million kW Fossil fuel 85 % Hydropower 15 %
AGRICULTURAL LAND	
4,000 km²	19,000 km²
1,960 km²	
GROSS DOMESTIC PRODUCT	
15,700 million USD	66,600 million USD
6.2 million	NB: no data available at the basin scale
POPULATION	
5 million people	9 million people
405,000	447,400

Sources: FAO Aquastat ; US EIA International Energy Statistics ; Word Bank , 2015.

ANALYSING NEXUS LINKAGES

Energy, water and land resources are closely linked in the Alazani/Ganykh Basin. Figure 16 provides an overview of the current status of nexus linkages. In the Alazani/Ganykh Basin land-water and energy-land links are particularly important.

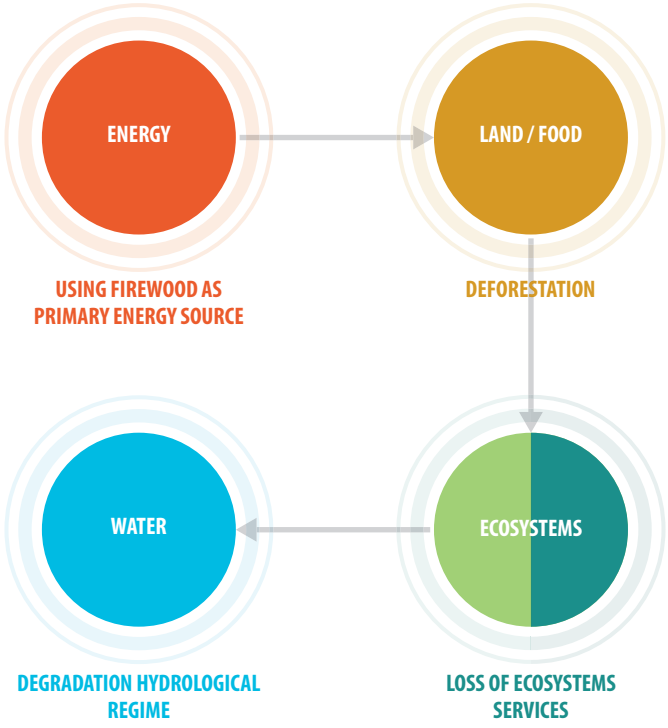
FIGURE 16
Nexus linkages in the Alazani/Ganykh Basin



Land and Water. Growth in agriculture and agro-industry requires a secure supply of water of adequate quality. Agricultural practices and infrastructure inherited from the Soviet era resulted in excessive water usage for irrigation, leading to swamping of large areas and, combined with poor drainage and the use of certain fertilizers, water salinization. In Georgia, 35 to 40 per cent of the water withdrawn from the river is lost.[123] At the same time, the lack of irrigation reduces opportunities to increase agricultural production.[124] Agricultural discharges are causing increases in the concentration of pollutants (such as nitrites, nitrates and phosphates) leading to algal proliferation, eutrophication and fish kills, and it also affects water use downstream, including drinking water supply and recreational use. Contaminated land from illegal and scattered open-air landfills contributes to water pollution by groundwater infiltration of pollutants or contact with river flows from the banks. Old storage sites for pesticides have in the past caused significant toxic contamination by leaching into the soil, but nowadays they represent a minor problem (Elseud, 2013).[125] The absence of legitimate sites for the collection and disposal of domestic waste in settlements located at the mouths of tributaries of the Ganykh also contributes to water pollution through groundwater infiltration.[126]

Energy and Land. Deforestation due to fuelwood collection is particularly pronounced in the upper Alazani in Georgia. Wood is harvested for heating and cooking purposes and mainly used in conventional stoves that produce high concentrations of particulate matter and smoke, a major cause of respiratory diseases. Although its use has been decreasing, firewood represents over 50 per cent of household fuel consumption in the basin.[127] In addition, deforestation reduces the water retention capacity of land, making it increasingly prone to flooding and its effects. It also leads to increased soil erosion, which will be made worse by frequent and intense flooding and subsequent landslides, the occurrence of which is expected to be exacerbated by climate change.[128] Sediment and mud negatively affect the performance and useable life of hydropower infrastructure, as well as irrigation and other types of infrastructure. They also affect riverine ecosystems and hydrological functions (Figure 17). Illegal logging for fuelwood drastically decreased in Azerbaijan after the expansion of the gas network to rural areas and the promotion of kerosene and other fuels suitable for heating and cooking in remote mountain areas.[129]

FIGURE 17
Example of nexus chain in the Alazani/Ganykh Basin



For the time being, water quantity is not a concern in the basin. Nevertheless, the links between land, water and energy resources will intensify in the future. Socioeconomic developments will drive a more intense use of resources in the Alazani/Ganykh Basin. However, not all the basin's resources will be affected in the same way. Water resources in particular will experience heavier impacts both from linkages to energy and land resources (Figure 18).

[123] Information provided by local experts (2013)

[124] According to a survey by the World Bank from 2012 on 3,000 households in Kakheti, '49 per cent of households considered the lack of irrigation or drainage as a severe or major constraint to rural investment.' *Source:* Project Information Document "Irrigation and Land Market Development Project", Georgia (P133828). (Washington D.C., World Bank, 2014).

[125] Ahmed Abou Elseud. *Desk study on water quality hotspots in the Kura Araks river basin, UNDP GEF project "Reducing transboundary degradation in the Kura Ara(k)s river basin",* (Tbilisi-Baku-Yerevan, UNDP, 2013).

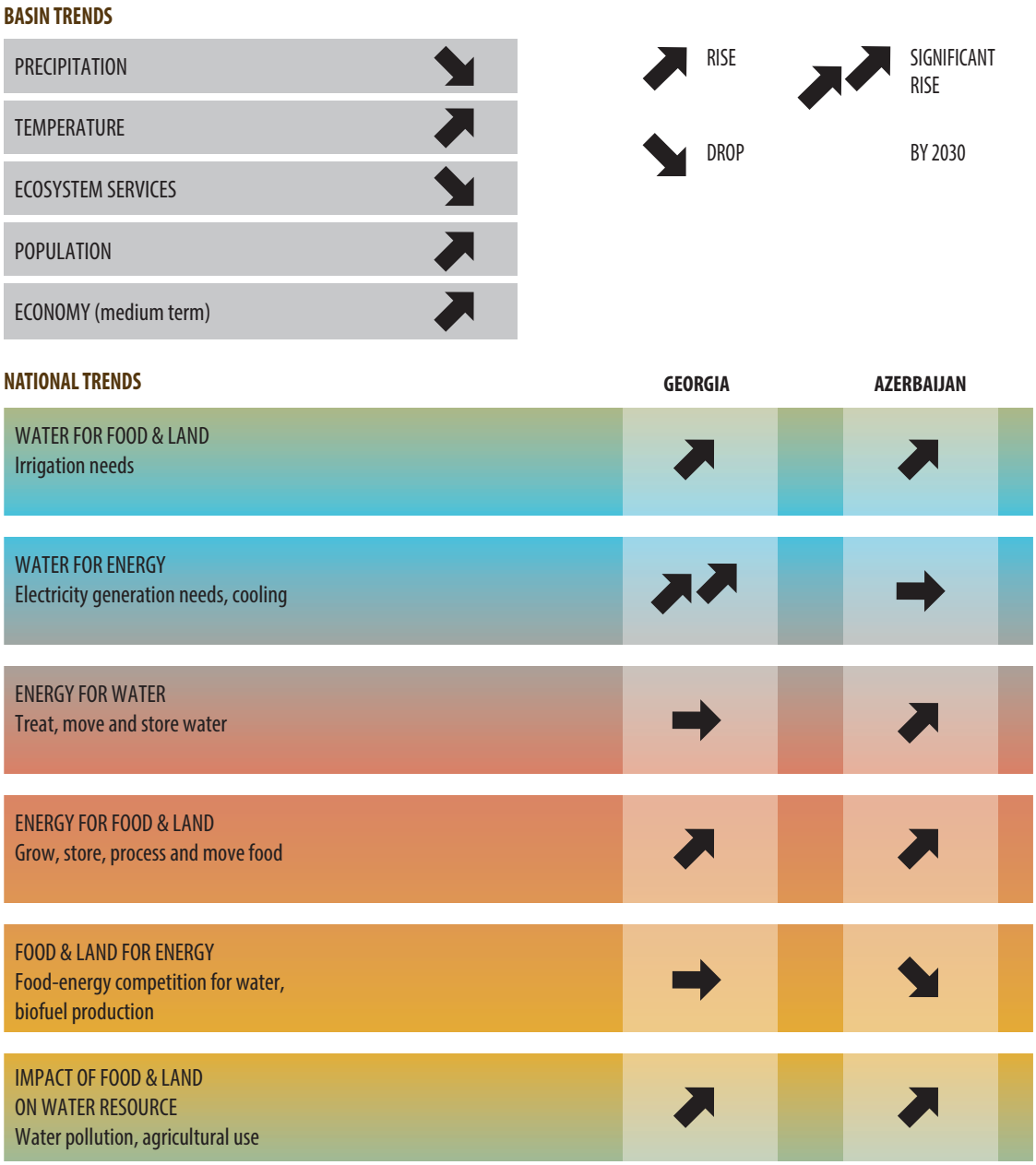
[126] Information provided by Azerbaijani authorities (2015).

[127] Information provided by local experts (2013).

[128] CENN, *Assessment of the Vulnerability to Natural Disasters and Climate Change for Upper Alazani Pilot Watershed Area & Plan of Mitigation and Adaptation Measures,* Integrated Natural Resources Management in Watersheds of Georgia Program. (Tbilisi, Caucasus Environmental NGO Network, 2014)

[129] Shamil Huseinov. Direct consultation on natural resources (2013).

FIGURE 18
Future trends among nexus linkages in the Alazani/Ganykh Basin



EXPLORING SOLUTIONS

The pilot nexus assessment of the Alazani/Ganykh River Basin includes the preliminary identification of possible solutions to improve the management of the basin's land, water, energy and environmental resources. These potential solutions have been classified under five headings: institutions, information, instruments, infrastructure, and international cooperation and coordination.

Institutions

- **Establishment and strengthening of basin governance** — a key element would be the finalization and signing of the draft bilateral agreement currently under negotiation on cooperation in the field of protection and the sustainable use of the water resources of the Kura River Basin. At the national level a supporting action would be to complete updating the national water legislation, reflecting the basin principle. Capacity-building at the municipal government level is an important prerogative for success.
- **Developing mechanisms to identify and incorporate the wider nexus impacts in sector-based policy development** – both at national level and at transboundary level (for example in the framework of the impending Kura agreement).
- **Engaging water-user sectors in the ongoing development of water laws, strategies and plans** – such as the updating of the Water Law which has been undertaken in Georgia or the development of the National Water Strategy in Azerbaijan.
- **Clarifying roles and responsibilities** – for example, for repairs and maintenance of irrigation infrastructure.

- **Leveraging the support of development partners** – technical and financial development partners (such as the EU, OECD, UNDP-GEF,[130] UNECE[130] or USAID)[132] play important supporting roles in the development and implementation of sectoral strategies. That support can be channeled to ensure that those sectoral strategies (like the new Energy Strategy for Georgia or intersectoral ones like the Strategic Action Plan for the Kura-Ara(k)s River Basin) take nexus linkages into account and include cross-sectoral actions.

Information

- **Improving the monitoring and assessment of basin resources and uncontrolled hotspots,** particularly basin resources exposed to increasing pressures (such as groundwater abstraction), and paying special attention to assessing the economic value of ecosystem services.
- **Assessing nexus linkages when developing sectoral plans or assessments** – such as energy assessments, agricultural assessments, or health assessments that take into account resource constraints and cross-sectoral impacts.
- **Developing and applying guidelines and drawing upon international experience** to improve sustainability in the location, design and construction of hydropower plants.[133]
- **Providing extension services to upgrade agricultural and forestry practices,** including crop selection, water management, and application of agro-chemicals, informed by cross-sector knowledge.

Instruments

- **Improving land use planning.**
- **Mapping the current structure of policy instruments** (such as subsidies and water allocation rights) and assessing their impacts in order to identify opportunities for improving alignment and coherence of policy instruments with policy objectives across different sectors.
- **Introducing instruments to apply the "polluter pays principle" for resource management and "beneficiary pays principle" for infrastructure financing,** including private companies, public companies and agencies, and households. Well-targeted economic instruments could motivate rational use of water, while at the same time contributing financially towards repairs and extending infrastructure. The need for this is particularly pressing in agriculture.
- **Implementing a policy mix to promote switching from fuelwood to modern fuels in the basin** particularly in the upper basin, and building on the experience of Azerbaijan, which relies on subsidies and the development of gas infrastructure. Since Georgia does not have a similar fossil fuel base, switching from fuelwood would likely require planning for electricity and fuel imports. Small hydropower plants could be developed, taking into account the constraints in the basin, which would seek to keep environmental impacts low.
- **Reforming agricultural support packages** so that they promote improved management of land, water, energy and environmental resources, for example, by moving towards sustainable and responsible use of water, including low-water intensity crops, and preparedness from the effects of climate change, for example, by training farmers in best farming practices.
- **Introducing instruments to better manage the water supply and sanitation** – they could include compulsory metering for households, the promotion of low flow appliances, and regulations for water re-use and recycling.
- **Developing environmental flow regulations** – this is particularly pressing because of the growing interest in developing hydropower in both countries. Environmental flows should be established case by case, taking into account the specificities of the river ecosystem while at the same time seeking consistency.
- **Stepping up enforcement of existing regulations** – for example regarding wastewater discharges or solid waste disposal.

Infrastructure

- **Investing in built infrastructure to ensure the preservation and protection of the basin's water resources** – from modernizing irrigation infrastructure to building new wastewater treatment plants.
- **Developing an approach to investing in flood management** that integrates natural infrastructure – such as ongoing reforestation and afforestation efforts, and built infrastructure.
- **Ensuring that new hydropower plants, driven by hydropower generation, are designed to maximize the benefits of multiple uses** – for example, building them in combination with irrigation or drinking water supply intakes, as well as minimizing impacts on the environment, for example, by preferring run-of-the-river type hydropower station designs.
- **Promoting the development of renewables** (other than hydropower) – such as the currently planned production of electricity and heat from biomass, solar, wind etc. on the Azerbaijani side of the basin.

International coordination and cooperation

- **Coordinating flood risk management measures,** including local infrastructure interventions, regular clearing and maintenance of river banks and emergency responses.
- **Coordinating water quality protection measures** with a focus on determining the type and scale of wastewater treatment facilities needed as well as on other interventions (such as water reuse) to reduce low-quality water discharges.
- **Facilitating information-sharing and mutual learning** – for example in the area of economic valuation of ecosystem services where Georgia has developed experience,[134] or for the introduction of water efficient irrigation technology where Azerbaijan has made progress.
- **Coordinating climate change adaptation plans and measures.**
- **Developing a strategic plan for the development of the hydropower potential** that incorporates a nexus approach for the identification of optimal hydropower growth and locations, and takes into account the cumulative effects of multiple hydropower plants. This would likely have benefits beyond the Alazani/Ganykh Basin area.

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[130] UNDP-GEF, Groundwater Resources in the Kura Ara(k)s River Basin. UNPD-GEF Project Transboundary Degradation in the Kura-Aras River Basin, 2007.

[131] UNECE, *Second Assessment of transboundary rivers, lakes and groundwaters*. (New York and Geneva, United Nations, 2011).

[132] UNECE, *Second Environmental Performance Review of Azerbaijan*, (New York and Geneva, United Nations, 2011).

[133] Instructive to this end is the "Common Guidelines for the Use of Small Hydropower in the Alpine Region" (2011) developed in the framework of the Alpine Convention or "Guiding Principles on Sustainable Hydropower" (2013) developed in the framework of the International Commission for the Protection of the Danube River (ICPDR).

[134] Georgia was assessed in the framework of a global initiative, the Economics of Ecosystems and Biodiversity (TEEB) that focused on drawing attention to the economic benefits of biodiversity. UNEP, *TEEB Scoping Study for Georgia*. (Geneva, United Nations Environment Programme, 2013). Available from: http://www.teebweb.org/

IDENTIFYING THE BENEFITS OF ADOPTING A NEXUS APPROACH

By adopting a nexus approach to the management of the Alazani/Ganykh Basin's resources, Azerbaijan and Georgia can exploit many potential benefits. The results of a rapid scoping of those benefits are summarized in Table 15, which follows the analytical framework described in section 'The benefits of adopting a nexus approach' in chapter 4.

TABLE 15
The benefits of transboundary cooperation in the management of the Alazani/Ganykh Basin resources

	On economic activities	Beyond economic activities
From improved management of basin resources	**Economic benefits** • Increased productivity and profitability of agriculture • Preservation and development of aquaculture • Avoiding hydropower generation losses due to floods and reservoir siltation • Cost savings in drinking water treatment • Reduced economic losses from floods • Reduced public spending on emergency situations and repairing damage • Expansion of tourism industry	**Social and environmental benefits** • Health benefits from reduced indoor air pollution • Reductions in human losses caused by floods • Reductions in unemployment • Poverty reduction and increased living standards • Recreational use by local communities • Preservation of forest habitats • Carbon sequestration
From increased trust between Azerbaijan and Georgia	**Regional economic cooperation benefits** • Increased trade in energy carriers (such as electricity, natural gas, kerosene)	**Geo-political benefits** • Alignment to international and EU regulation • Reduced possibility of conflicts between Georgia and Azerbaijan

CONCLUSIONS AND RECOMMENDATIONS

The sustainable use and management of the Alazani/Ganykh Basin's resources is essential for the development of the riparian regions in Georgia and Azerbaijan. The basin has productive agricultural land, attractive landscapes, and abundant and good quality water resources. The agriculture and tourism sectors, which rely on those resources, are expected to drive development in the riparian regions. Improving energy access and affordability in rural areas contributes to improving rural livelihoods.

The basin's resources are increasingly under pressure. Economic development is driving water demand and water transfers to supply cities outside of the basin, raising pollution levels from agriculture and households, and increasing the exploitation of hydropower potential. Despite reduced levels of poverty, poverty is still an issue, and it is driving erosion and sedimentation owing to excessive logging for fuelwood and poor maintenance of river banks and irrigation infrastructure. In addition to erosion processes, flooding of agricultural plots also takes place.[135]

There are multiple linkages in the Alazani/Ganykh Basin between the different basin resources. Energy-land and land-water linkages are particularly strong. But second degree linkages are also relevant – for example, lack of modern fuels in the upper basin leads to deforestation for fuelwood collection, impacting on land erosion and sedimentation, which in turn affects water resources and populations (through flooding) as well as energy production through siltation of reservoirs and the impact of floods. Therefore, understanding the consequences of different policy options requires looking at the chain of indirect impacts across sectors, and quantifying them whenever possible.

This assessment has identified a menu of possible solutions to support the sustainable use and management of the basin resources. They include solutions related to institutions, information, instruments, investments, and international cooperation and coordination. Often, coherent packages of measures will need to be devised, for example, with regard to agricultural support or the promotion of fuel switching. A nexus perspective should inform the selection of measures, for example, in the development of sustainable and multi-purpose renewable energy sources.

The current level of cooperation at the technical level is good, but management of the nexus requires stronger transboundary governance. The two countries are currently negotiating a transboundary agreement for the Kura Basin to which the Alazani-Ganykh belongs. Finalizing that agreement represents a valuable opportunity for engaging different water-using sectors in cooperating at the transboundary level.

More intense transboundary cooperation on the integrated management of basin resources will bring additional real benefits. It will allow Georgia and Azerbaijan to exploit complementarities in their resource bases (e.g. Georgian forests, Azerbaijani gas) to optimize resources development as well as risk management at the basin scale (e.g. coordinated hydropower development, coordinated flood management) to effectively protect the resource base for regional economic development, and to generate new economic opportunities (e.g. through more intense energy trade). There are certainly opportunities for the two countries to learn from each other, for example, Georgia would benefit from Azerbaijani experience in promoting the switch from fuelwood to modern fuels, and Azerbaijan could learn from the Georgian experience in economic valuation of ecosystem services.

Ultimately, stronger and more coherent national policies are needed to "manage the nexus". To a large extent, the dynamics between the resources and sectors at the transboundary level are explained by national developments. Intersectoral planning needs to be strengthened, which will require improved information exchange, but also mechanisms to take into account cross-sectoral impacts when carrying out sector planning. The preparation of the National Water Strategy of Azerbaijan and the updating of the Georgian Water Law provide an opportunity to strengthen intersector coordination of water-user sectors. Similarly, the development of the new Energy Strategy for Georgia represents an opportunity to consider the chain of impacts on other sectors (agriculture, forest, tourism, urban development) of different energy policy options.

This pilot nexus assessment only provides an overview of the importance of the basin's resources, the intersectoral linkages, potential solutions and untapped benefits. Further analytical, stakeholder engagement and planning work will be needed to identify the precise technical, policy or governance related measures and investment options required to address the challenges and seize the opportunities.

The benefits and achievements that transboundary cooperation in Alazani/Ganykh Basin will bring about will in many cases extend beyond its borders. This is particularly the case at the Kura Basin scale, but also at the national level. For example, an eventual agreement on coordinated flood control could be easily upscaled.

[135] In recent years during the period of floods, the river washed off hundreds of hectares of agricultural land area in Georgia, significantly reducing land area that belonged to private farms.

CHAPTER 6

Summary of the assessment of the water-food-energy-ecosystems nexus in the Sava River Basin

INTRODUCTION

AIM, OBJECTIVES AND SCOPE

The assessment of the water-food-energy-ecosystems nexus in the Sava River Basin aims to support transboundary cooperation by Sava countries in the areas of water, energy, food and environmental policies by strengthening the knowledge base for integrated policy development and decision making.

The specific objectives of this nexus assessment are:

- to identify key drivers of the different sectors that can cause adverse pressures and impacts on water, energy, ecosystems and food security;
- to draw implications for the transboundary river basin based on national findings;
- to outline the potential to support and increase additional benefits that could be achieved in the basin through more coordinated policies and actions, and through transboundary cooperation;
- to identify policy measures and actions that could alleviate negative consequences of the nexus and help to optimize the use of available resources (under future environmental and climate constraints).

The assessment also contributes to the implementation of the Framework Agreement on the Sava River Basin (FASRB): further integration of water policy with other policies, as well as further dialogue with key sectoral stakeholders, have been set in the Strategy on Implementation of the FASRB as specific objectives in the field of river basin management.

ASSESSMENT PROCESS

The Nexus Assessment in the Sava Basin was carried out with and at the request of the International Sava River Basin Commission (ISRBC). The analytical work was carried out by the Royal Institute of Technology KTH, in Stockholm (technical aspects) and by an independent consultant (governance). It was complemented by modelling by the European Commission's Joint Research Centre (JRC) in the framework of the Danube Water Nexus project.

The Sava Nexus assessment made use of a multi-stakeholder approach involving representatives from the different sector ministries and various interest groups relevant to the nexus from five Sava countries: Slovenia, Croatia, Bosnia and Herzegovina, Serbia and Montenegro.

Information for the pilot Nexus Assessment of the Sava Basin was gathered through (i) an inter-sectoral workshop that took place in Zagreb from 4 to 6 March 2014; (ii) two questionnaires, one factual (filled by local experts) and one perception-based one (distributed at the inter-sectoral workshop); and (iii) a desk-review of relevant documentation.

The consultation on the findings involved a circulation of the draft assessment for review and comments to the authorities of the riparian countries and stakeholders in January 2015, consultation through the website of the International Sava River Basin Commission (ISRBC) on 10 April 2015 and organization of a stakeholder consultation workshop on 25 May 2015, Zagreb.

BASIN OVERVIEW

The Sava Basin is a key basin in the Western Balkans. It covers considerable parts of Bosnia and Herzegovina, Croatia, Montenegro, Serbia, Slovenia, and a very small part of Albania.[136] Indeed, a large part of the population of most riparian countries lives in the basin: 75 per cent in Bosnia and Herzegovina, 61 per cent in Slovenia, close to 50 per cent in Croatia, over 30 per cent in Montenegro and close to 25 per cent in Serbia. A significant share of water, hydropower, land area and economic activity is based in or derived from the basin – for example 53 per cent of the riparian countries[137] electricity generation capacity is located within the basin.

The Sava Basin is part of complex network of transboundary waters. The Sava River, which emerges in the mountains of western Slovenia and flows into the Danube in Belgrade (Serbia), is the Danube's third longest tributary (about 945 km) and the largest by long term average discharge (1,722 m^3/s, at its mouth). In turn, the Sava River receives water from a number of tributaries, many of which are also transboundary – such as the Drina.

The Sava Basin has a varied morphology, geology, and ecology. The upper part is dominated by rugged mountains (the Alps and the Dinarides), while the middle and lower parts are characterized by flat plains and low mountains -- elevation varies between 2,864 m a.s.l. and 71 m a.s.l. Diverse geological structures and a complex tectonic setting determine the type of aquifers that occur: the Pannonian area with dominant inter-granular aquifers, the Dinarides with mostly limestone aquifers, and some karstic areas. The basin hosts large lowland forests, the largest complex of alluvial wetlands in the Danube Basin (Posavina - Central Sava Basin), seven designated Ramsar sites,[138] and a number of areas of ecological importance are under national protection status.[139] The main geographical features of the Sava Basin are shown in the map in figure 19.

The Sava Basin's natural resources are key for the current and future development of the riparian countries. Water and land resources support significant agricultural production, power generation, navigation – see Figure 19. The Dinaric Karst Aquifer is the main source of drinking water for some countries. The presence of some intact floodplains supports both flood mitigation and biodiversity conservation. Parts of the basin enjoy a very favourable environment for hydropower generation. Thanks to its pristine natural ecosystems and the availability of recreational water-based transport, the Sava Basin already attracts tourism, and has the potential to attract more tourism-related activities. Forests and wetlands have provided an array of ecosystem services to people living in the area from aesthetics to wild food, fuel and timber, and are interwoven with local culture and livelihoods. The basin's resources also contribute to significant reductions in greenhouse gas emission due to the low carbon electricity production taking place in the basin. This includes high levels of hydropower production, cooling of the region's nuclear power plant and a number of thermal power plants, supplying balancing services for the introduction of solar and wind, as well as the high levels of carbon dioxide sequestered in forests and wetlands.

[136] Due to the small share of the river basin, Albania was not involved in the assessment process.

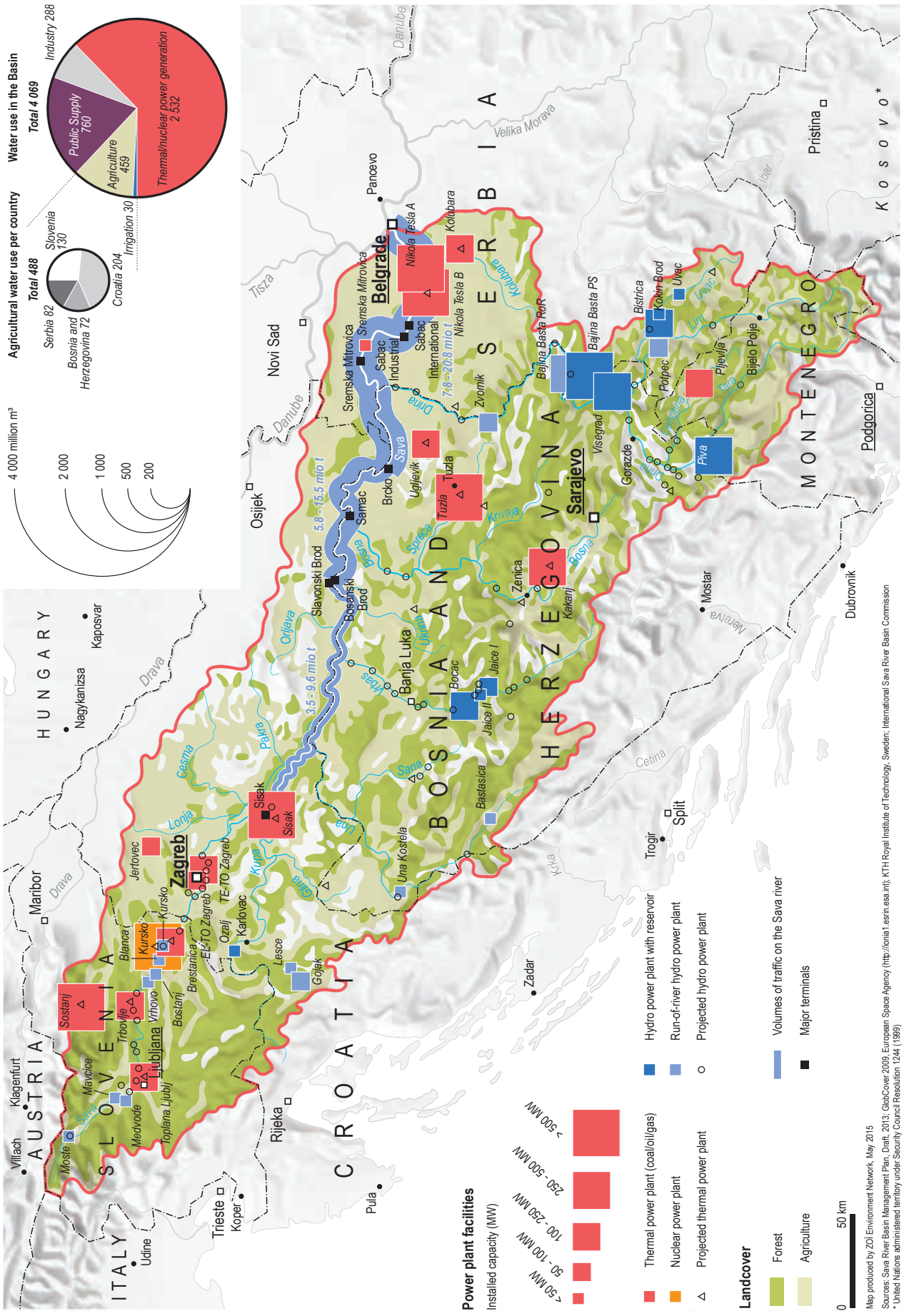
[137] In this case Bosnia and Herzegovina, Croatia, Montenegro, Serbia, Slovenia

[138] Cerknica Lake (SI), Crna Mlaka, Lonjsko Polje, Mokro Polje (HR), Bardača (BA), Zasavica, Obedska bara and Peštersko polje (RS)

[139] ISRBC, *Sava River Basin Management Plan* (International Sava River Basin Commission, 2014).

FIGURE 19
THE SAVA RIVER BASIN

Map of the Sava River Basin showing the main geographical features and illustrating the distribution of nexus components of energy and food (land and agriculture), and indicators of agricultural production at national level. Hydropower is not included in the pie chart of major water uses.



DESCRIBING THE GOVERNANCE CONTEXT

Basin level governance

Governance of water resources. Water governance at basin-level is well developed. The Framework Agreement on the Sava River Basin (FASRB) provides the legal and institutional framework for cooperation, while the International Sava River Basin Commission (ISRBC) operates as the implementing body of the FASRB. The ISRBC provides a framework for the establishment of joint objectives that can be implemented by countries in different stages of development, for example through adoption of the "Policy on the Exchange of Hydrological and Meteorological Data and Information in the Sava River Basin." It also serves as a forum where different interests (such as recreation and tourism, industry, agriculture, or navigation) are represented and issues of common concern can be discussed, as well as agreements reached about the coordinated implementation of relevant activities. The ISRBC's Public Participation Plan, finalized in 2014, presents a good basis for further activities on strengthening public participation and stakeholder involvement in implementation of the FASRB. The general public is informed of progress with FASRB implementation through the ISRBC's website[140] as well as various publications and releases. A proposed Sava Water Council would increase stakeholder involvement and give a greater voice to stakeholders in the planning stages.[141]

Governance of other basin resources. Involving the energy and agricultural sectors in basin level coordination is still at an early stage. Closer coordination of Sava countries in the energy sector will likely be driven by EU policies – such as the comprehensive EU strategy on climate change and energy currently under development. Through flood risk management coordination — implementation of the EU Floods Directive — attention is paid to land use aspects.

Cross-sectoral governance at basin level. The ISRBC coordinates the development of various intersectoral plans, among them the River Basin Management Plan according to the European Union Water Framework Directive (WFD).[142] The Strategy on Implementation of the Framework Agreement on the Sava River Basin envisages further integration of water policies with other sector policies. Financial aspects of multi-level governance relevant for a nexus approach are routinely considered within the FASRB.

Supra-basin governance

European Union. The European Union (EU) has a major influence in developments in the Sava Basin. While only Slovenia and Croatia are members of the EU, all Sava countries have taken steps towards EU accession. As a consequence, all Sava countries have made commitments derived from the *acquis communautaire* (EU Law) that affect water, energy, environment and food (agriculture and land management) policies – such as the EU Water Framework Directive and its daughter directives,[143] different energy directives and strategies, the Common Agricultural Policy, the Rural Development Policy, or a number of environment directives such as the Habitats Directive. For Slovenia and Croatia, EU membership means that compliance with the acquis is a matter of treaty obligation, and is enforced by the European Commission as the guarantor of the Treaties. For non-member states, commitments are a part of the closure of particular chapters in the accession process, and are subjected to progress monitoring, without specific sanctions other than delay in accession. The Sava countries typically have specific institutions dedicated to EU integration and may adopt specific national strategies for approximation or transposition. The EU integration process also includes possibilities for financing activities aimed at reaching cross-sectoral integration goals (see Box 12).

BOX 12.
Access to EU funds

The process of EU accession generates costs as well as opportunities for funding. The Sava countries include EU member States (Slovenia, Croatia), EU candidate countries (Serbia, Montenegro) and potential candidates (Bosnia and Herzegovina). The water-related EU directives, especially the Urban Waste Water Treatment Directive, are expected to place a substantial financial burden on the Sava countries. At the same time Sava countries can access a number of EU funds. EU member States can access funds from the LIFE program (for environment and nature conservation and biodiversity), the Cohesion Fund (for environment, energy efficiency and renewable energy), and the Common Agricultural Policy (agriculture). Non-EU countries can access EU funds through the Instrument for Pre-Accession Assistance (IPA), which provides support in areas such as cross-border cooperation, regional development and environment.

Source: http://ec.europa.eu/

Danube Basin. Since the Sava Basin is a sub-basin of the Danube Basin, the overall governance of the Danube Basin influences decisions made at the level of the Sava Basin. Regional cooperation on the Danube in the area of water is governed in part by two conventions - the Danube River Protection Convention, under which the International Commission for the Protection of the Danube Basin (ICPDR) is established, and the Convention Regarding the Regime of Navigation on the Danube (Belgrade Convention), under which the Danube Commission is established. Cooperation between the ISRBC and the two Danube Commissions (ICPDR and Danube Commission) is formally based on memoranda of understanding signed with both commissions separately. The ISRBC participates actively in projects and initiatives across the Danube River Basin, One such example of intersectoral cooperation is the process of implementation of the Joint Statement on Guiding Principles for the Development of Inland Navigation and

[140] www.savacommission.org

[141] GWP. Public Participation Plan: Sava River Basin (Athens, Global Water Partnership, 2014). [The plan was endorsed by the ISRBC in 2014.]

[142] Sava River Basin Management Plan. (Zagreb, International Sava River Basin Commission, March 2013). Available at http://www.savacommission.org/srbmp/en/draft

[143] Directives on groundwater and on priority substances: Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 concerning the protection of groundwater against pollution and deterioration; and so-called Priority Substances Directive, that is, Annex II of the Directive 2008/105/EC concerning Environmental Quality Standards

Environmental Protection in the Danube River Basin coordinated jointly by the ICPDR, Danube Commission and ISRBC, together with the European Commission.[144] Cooperation is enhanced by mutual participation at sessions, expert group meetings and other events of the commissions. The ISRBC has also played a role in the implementation of the EU Strategy for the Danube Region.

UNECE region. The Sava countries are parties to the Espoo Convention on Transboundary EIA as well as to its SEA Protocol (except Bosnia and Herzegovina which is a signatory). They take part in regional water cooperation mechanisms, such as the UNECE Water Convention (all riparian states are parties), and its Water and Health Protocol (Albania, Bosnia and Herzegovina, Croatia and Serbia are parties, while Slovenia is a signatory).

National level governance

Legal and institutional frameworks. In Sava countries, the national administrations have achieved substantial progress in harmonization with EU legislation.[145] The local level remains of special importance for creating rules and norms that are grounded in the specifics of the locality and implemented by the local authorities. At the same time, coherence between national policies and their local implementation needs to be ensured.

Multi-level governance. The Sava countries vary greatly in terms of institutional structures and degree of decentralisation. For example, Bosnia and Herzegovina's constitutional framework has led to the development of relatively few national-level strategies, and existing national-level strategies face implementation problems at the level of entity[146] (or in some cases cantonal) governments. Given that 40 per cent of the Sava River Basin is within the territory of Bosnia and Herzegovina, this is a significant factor to be taken into account in basin-wide planning and implementation efforts. By contrast, Slovenia does not have subnational level institutions between the State Government and local government,and the implementation of national strategies, laws and regulations is under the control of national level institutions.

Cross-sectoral governance. Thanks to better understanding of substantive issues and changes in institutional set-up and procedures, decision-making processes increasingly integrate cross-sectoral issues. For example, periodic state of the environment reports contribute to informing the development of policies in sectors such as industry, agriculture and energy. Nevertheless, obstacles to multi-sectoral governance remain.

Water governance. For some time, international institutions and assistance programmes have identified the problems related to water management in some Sava riparian countries to include "inadequate institutional structures".[147] The volatility of the configuration of ministries and their constant restructuring poses problem for effective governance. Sometimes water management falls under the competencies of multiple ministries, such as in Montenegro where water competencies are divided among six ministries with the Ministry of Agriculture and Rural Development in the lead. Some countries have established horizontal multi-stakeholder coordination bodies, with varying degrees of effectiveness. Local governments play a key role in water supply, wastewater collection and sewerage services, and wastewater treatment, while water management enterprises perform operational activities in the field of water management. Meanwhile, the application of the subsidiarity principle has accelerated the trend towards shifting responsibility for financing of environmental and other infrastructure towards decentralised local government, particularly for wastewater collection and treatment infrastructure. However, while public needs may be better identified at the local level, greater decentralisation has resulted in fragmentation of efforts and in insufficient capacity and resources at the local level. In some riparian countries, the lack of a regional level authority combined with a high degree of municipality autonomy has created a governance gap in environmental performance.

Policy development in nexus sectors. International cooperation has led to the adoption of a number of measures at national level. Many national strategies and action plans are driven at least in part by EU requirements or requirements associated to international funding. For example, Croatia is typical of the region in terms of adoption of various strategic documents on environmental aspects relevant to nexus issues, including the Environmental Protection Strategy, the Environmental Action Plan, the Strategy and Action Plan for the Protection of Biological and Landscape Diversity, the Waste Management Strategy, and the Waste Management Plan, among others.[148]

[144] More information on the Joint Statement, concluded in October 2007, is available from: www.icpdr.org. The 6th Meeting on implementation of the Joint Statement was held 10–11 September, 2015 in Vienna.

[145] UNECE, *Second Assessment of Transboundary Rivers, Lakes and Groundwaters*. (New York and Geneva, UNECE, 2011).

[146] Bosnia and Herzegovina is politically decentralized and comprises two governing entities, the Federation of Bosnia and Herzegovina and the Republika Srpska, with Brčko District as a de facto third entity.

[147] World Bank. Issues and direction. Vol. 1 of Water resources management in South Eastern Europe. (Washington, D.C., International Bank for Reconstruction and Development, 2003). Amar Čolakhodžić, Marija Filipović, Jana Kovandžić and Stephen Stec, The Sava River: Transitioning to Peace in the Former Yugoslavia. In *Water and Post-Conflict Peacebuilding* (Routledge, 2014).

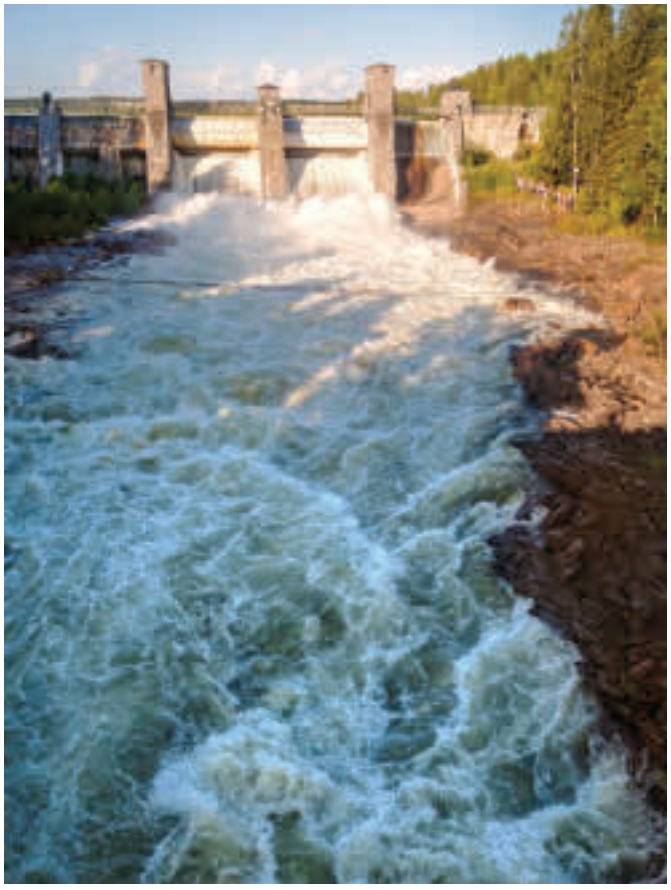
[148] UNECE, *2nd Environmental Performance Review of Croatia*. (New York and Geneva, United Nations, 2014).

Policy implementation on the nexus resources. The Sava countries vary greatly in terms of implementation capacities and resources. The water and energy sectors are highly regulated, and biodiversity protection is also generally under state supervision, due to the need to meet certain protection goals and in some cases to implement stringent conservation principles.

- **Water.** The EU *acquis communautaire* in the field of water management has profound importance for furthering sustainable water use and pollution reduction and control. Slovenia and Croatia are implementing the requirements of the Urban Waste Water Treatment (UWWT) Directive according to the commitments and deadlines set down in the respective accession treaties with the EU (i.e. 2017 for Slovenia and 2023 for Croatia), while the approximation of the water-related directives has advanced at different stages in the Sava countries that are not EU Member states.[149] For example, in Bosnia and Herzegovina in 2011 the Water Framework Directive was fully approximated in Republika Srpska, and 90 per cent approximated in Federation Bosnia and Herzegovina; while the corresponding figures for the Urban Waste Water Treatment Directive were 41 per cent and 35 per cent respectively.
- **Agriculture.** Governance mechanisms involving self-regulation of private actors are especially significant in the agricultural field, given the fact that small farmers own more than 85 per cent of the total agricultural area in the basin and the economic importance of the agricultural sector is high. While at national level all Sava countries have ministries of agriculture, local farmers are important self-regulating actors who often apply good agricultural practices voluntarily. Agricultural practices are largely determined through relationships on a national level among farmers (often self-organized into cooperatives) and local authorities, with linkages to other interest groups such as environmental authorities, consumer groups and other NGOs.
- **Energy.** All the Sava River Basin countries belong to the Energy Community either as EU member States or as parties to the Energy Community treaty. The treaty provides for the creation of an integrated energy market (electricity and gas) among the European Union (EU) member States and other contracting parties. The European Council adopted the 2030 Framework for Climate and Energy Policies that includes targets on, for example, greenhouse gas emissions, the share of renewable energy and energy efficiency.[150]
- **Environment.** While best practices in environmental permitting are promoted through various mechanisms (including EU legislation, OECD Guidelines and expert networks), in some countries the water permit is still separate from other aspects of integrated permitting. As EU members, Croatia and Slovenia have transposed the Integrated Pollution Prevention and Control (IPPC)[151] and Seveso directives[152] into the national legislation, but the other Sava countries have also introduced IPPC into their legislation. While understaffing is still a problem, capacities of inspectorates have increased in recent years and national inspection authorities play an important role in enforcement and in ensuring compliance with relevant regimes. Standards for permitting, inspection and enforcement with regards to facilities covered under the IPPC and Seveso frameworks include methodologies for coordination with stakeholder agencies. Some Sava countries have in place environmental funds, and for example in Bosnia and Herzegovina, the entity funds became operational in 2010.

Monitoring in nexus sectors. Monitoring capacities vary widely throughout the basin. There is no basin-level monitoring system, but national monitoring systems are gradually becoming better integrated. However, the region is still characterized by highly specialized bodies that possess specific information relevant to their responsibilities, with few mechanisms for sharing of information, accessibility of information (particularly by the public) and comparability of information. Some monitoring capacities have improved (e.g. water quality monitoring in the framework of the ICPDR), while others remain basic (e.g. biodiversity monitoring). A major focus of resources in this area should be on developing broad, open, transparent and efficient platforms for reliable, high-quality data to serve as the foundation for high-quality decision-making. The development of such platforms is another area where public capacities, knowledge and expertise can be deployed.

Public participation and information. The Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (Aarhus Convention) and the EU legislation adopted for its implementation facilitate coordination and cooperation across sectors. The Sava countries have developed extensive practice in implementation of provisions related to access to environmental information and public participation in environmental decision-making. More needs to be done, however, to aggregate the outcomes of public participation at specific decision-making levels in order to take these into account at more strategic levels. In addition, public participation has to be maintained and even strengthened in connection with specific-level decisions that are highly relevant to the nexus approach, such as in connection with climate change adaptation.



149 OECD, *South East Europe Competitiveness Outlook 2015*. (Paris, OECD, 2015) [draft].

150 A policy framework for climate and energy in the period from 2020 to 2030, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Brussels, 22.1.2014 COM(2014) 15 final.

151 Directive 2008/1/EC of the European Parliament and of the Council of 15 January 2008 concerning integrated pollution prevention and control.

152 Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC.

FIGURE 20
Overview of institutions relevant to managing the components of the nexus in the Sava River Basin.

Regional level	European Union[a]				
Subregional level	Energy Community				
	Danube Commission				
	International Commission for the Protection of the Danube River				
Basin level	International Sava River Basin Commission				
	BOSNIA AND HERZEGOVINA	**CROATIA**	**MONTENEGRO**	**SERBIA**	**SLOVENIA**
State Government	Ministry of Foreign Trade and Economic Relations	Ministry of Environmental and Nature Protection	Ministry of Sustainable Development and Tourism	Ministry of Agriculture and Environmental Protection	Ministry of Environment and Spatial Planning
	Ministry of Communications and Transport	Ministry of Construction and Physical Planning	Ministry of Agriculture and Rural Development	Ministry of Mining and Energy	Ministry of Infrastructure
Entity level (Bosnia and Herzegovina only)	**Federation of Bosnia and Herzegovina** Ministry of Environment and Tourism; Ministry of Energy, Mining and Industry; Ministry of Agriculture, Water Management and Forestry; Ministry of Physical Planning; Ministry of Transport and Communications **Republika Srpska** Ministry of Industry, Energy and Mining; Ministry of Agriculture, Forestry and Water Management; Ministry of Spatial Planning, Civil Engineering and Ecology; Ministry of Transport and Communications	Ministry of Agriculture	Ministry of Economy	Ministry of Construction, Transport and Infrastructure	
		Ministry of Economy			
		Ministry of Maritime Affairs, Transport and Infrastructure			
Committees and agencies	State Electricity Regulatory Commission;	National Water Council	Energy Regulatory Agency	Environmental Protection Agency	Institute for Water
	Entity level energy agencies	Hrvatske vode	Environment Agency	Energy Agency	Environment Agency
		Environment Agency	Directorate for Water Management		
		Energy Regulatory Agency	National Water Council		
Regional level	Regional Water(shed) Agencies	Regional government		Provincial government	
		Hrvatske vode - Regional Water Management Divisions		Regional Water Agencies: - Srbijavode - Beograd Vode - VodeVojvodine	
Energy producers	Elektroprivreda Bosne i Hercegovine	Hrvatska Elektroprivreda (HEP Group)		Elektroprivreda Srbije	ELES Ltd., Electricity Transmission System Operator
Local level	Canton and local government water supply and sewage enterprises	Local government	Local government	Local government water supply and sewage enterprises	Local government water supply and sewage public companies

Sources: Developed in the present assessment using information from the literature review and inputs from local experts (see "Annex on institutional governance and legal frameworks") available as "Annex on main regulations" among the documents of the third meeting of the Task Force on the Water-Food-Energy-Ecosystems Nexus. Available from: www.unece.org/index.php?id=38157#/

[a] While only Slovenia and Croatia are member of the EU, all Sava countries have taken steps towards EU accession. As a consequence, all Sava countries have made commitments derived from the *acquis communautaire* (EU Law).

IDENTIFYING DRIVERS OF PRESSURES ON BASIN RESOURCES

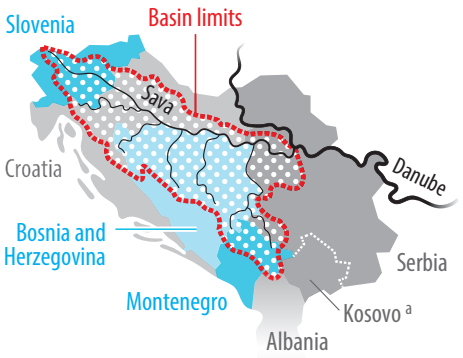
Use of water, land and energy resources in the Sava Basin will increase over the next 15 years. Figure 21 illustrates how the riparian countries compare in terms of resource base (freshwater, installed energy generation capacity, land resources) as well as economic and demographic size. Water usage for irrigation remains small for the time being but is expected to increase. Even if the countries in the basin have energy efficiency targets and policies, energy generation is also set to expand – partly through renewable sources. Indeed, energy security and trade are key concerns of the systems expansion.

Economic development will be the main driver of the expected expansion in resource use in the basin. Economic activity in the Western Balkans is expected to grow faster than the EU average. Efforts to maximise job creation will continue to be important in the region. This is likely to affect in particular resource-based sectors, such as agriculture (and agro-industry) and tourism (including eco-tourism and water-transport tourism). Agriculture in the Sava Basin currently represents between 5-10 per cent of total employment in the region (i.e. all riparian countries), while larger employment potential linked to potential expansion of agricultural area (which currently represents 42 per cent of the total Sava Basin area) and agro-industries. The use of Sava Basin's river network for transport (of goods as well as people for recreational purposes) will intensify with economic growth – but in order maintain the transport routes, sedimentation and river levels need to be maintained.

Climate change policies will affect the relative pressures on different resources. Each riparian will be subject either to strict EU targets[153] and / or targets they communicate to the United Nations Framework Convention on Climate Change (UNFCCC). Key to meeting these will be the deployment of more hydropower, other renewable energy technology, maintaining terrestrial carbon stocks (in wetlands and forests as well as land-use change). Adapting to climate change is a key challenge faced by all riparian's. This may include facing lower water availability and higher water requirements for example in agriculture, as well as ensuring adequate flows of water to maintain ecological systems.

[153] In the area of climate change and energy sustainability, the targets of Europe 2020 strategy are as follows: reduction of greenhouse gas emissions at least by 20 per cent lower than 1990, 20 per cent of energy from renewable energy sources and 20 per cent increase in energy efficiency. *Source:* EUROPE 2020: A strategy for smart, sustainable and inclusive growth, Communication from the Commission COM(2010) 2020 final (Brussels, 3 March 2010).

FIGURE 21
Key indicators describing the resources and socio-economics of the Sava countries



SAVA BASIN

River length **945 km**

River basin area **97,713 km²**

Water use **4,069 million m³/year**

SLOVENIA	CROATIA	BOSNIA AND HERZEGOVINA	SERBIA	MONTENEGRO
TOTAL RENEWABLE FRESHWATER RESOURCES				
Sava basin share: 18,600 million m³/year 31,870 million m³/year of which, water withdrawal 942 million m³ Agriculture 0.2% Industry 82.3% Municipal 17.6%	37,300 million m³/year 105,500 of which, water withdrawal 629 million m³ Agriculture 1.4% Industry 13.7% Municipal 85%	35,500 million m³/year 37,500 million m³/year of which, water withdrawal 329 million m³ Agriculture [no data] Industry 14.8% Municipal no data	8,400 162,200 of which, water withdrawal 4,121 million m³ Agriculture 1.9% Industry 81.6% Municipal 16.6%	19,700 million m³/year of which, water withdrawal 161 million m³ Agriculture 1.1% Industry 39% Municipal 59.9%
INSTALLED ELECTRICITY GENERATING CAPACITY & HYDROPOWER				
3.4 million kW of which Hydropower 1.3 million kW * Hydropower 37% Fossil fuels 36% Nuclear 21% Other renewables 6%	4.2 million kW of which Hydropower 2.1 million kW * Hydropower 51% Fossil fuels 45% Other renewables 4%	4.3 million kW of which Hydropower 2.15 million kW Hydropower 50% Fossil fuels 50%	8.8 million kW of which Hydropower 2.8 million kW * Hydropower 32% Fossil fuels 63% Other renewables 5%	0.9 million kW of which Hydropower 0.7 million kW Hydropower 76% Fossil fuels 24% * including pumped storage
AGRICULTURAL LAND				
4,900 km² of which 1% is irrigated	13,600 km² of which 1% is irrigated	21,500 km² [No irrigated land (or negligible)]	51,200 km² of which 0,5 % irrigated	5,200 km² [No irrigated land (or negligible)]
GROSS DOMESTIC PRODUCT				
48,000 million USD	57,900 million USD	17,800 million USD	45,500 million USD	4,400 million USD
POPULATION				
2 million of which 1,220 thousand people in the Sava basin (61%)	4.3 million 2,150 thousands (50%)	3.8 million 2,850 thousands (75%)	7.2 million 1,800 thousands (25%)	600,000

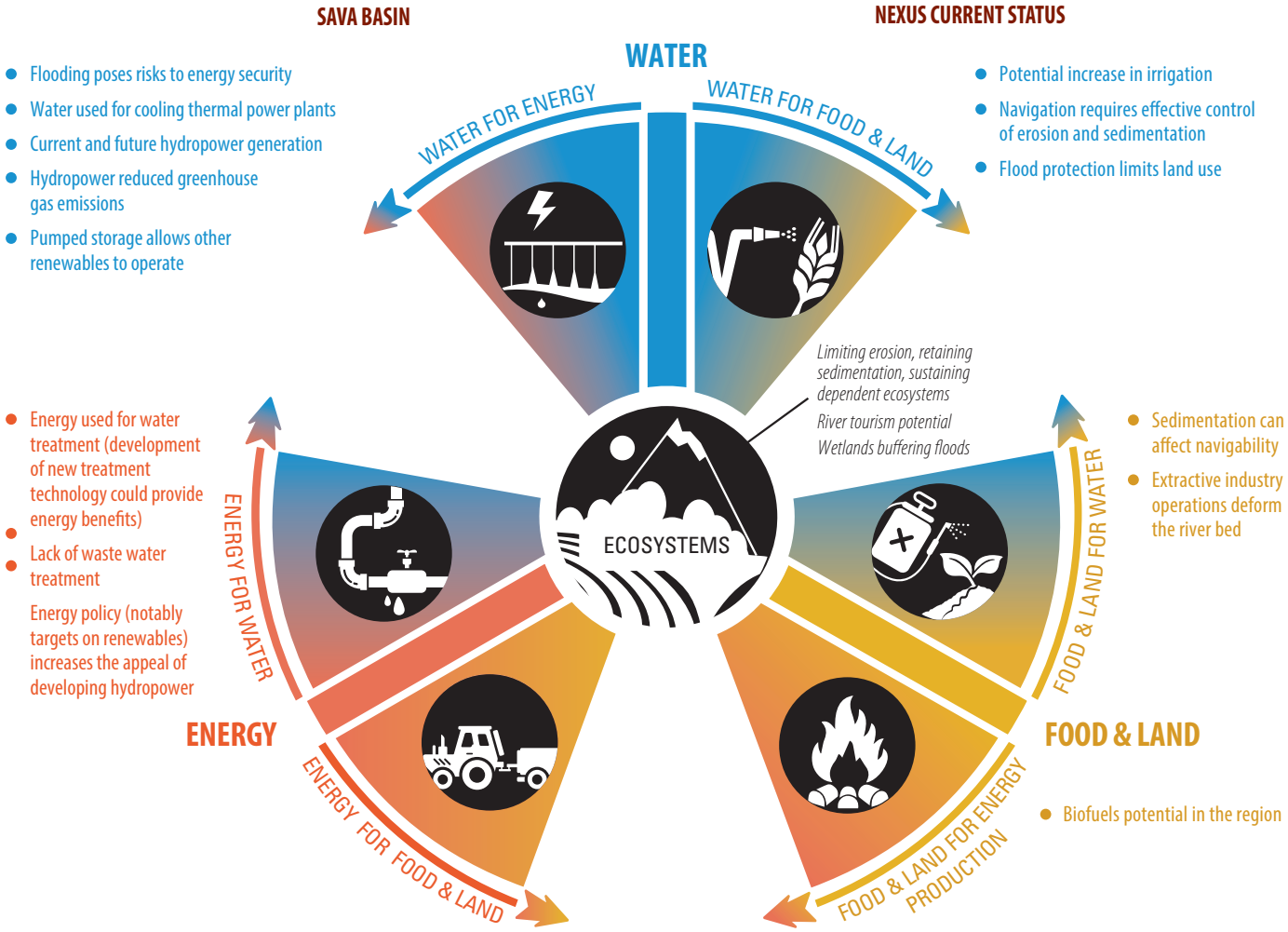
Sources: FAO Aquastat; US EIA International Energy Statistics; International Sava River Basin Commission; Word Bank, 2015.

[a] United Nations administered territory under Security Council Resolution 1244 (1999).

ANALYSING NEXUS LINKAGES

Energy, water and land resources as well as ecosystem services are closely linked in the Sava Basin. Figure 22 provides an overview of the current status of the nexus linkages. In the Sava Basin, energy-water and water-land links are of particular importance, and therefore described below in more detail.

FIGURE 22
Nexus linkages in the Sava Basin

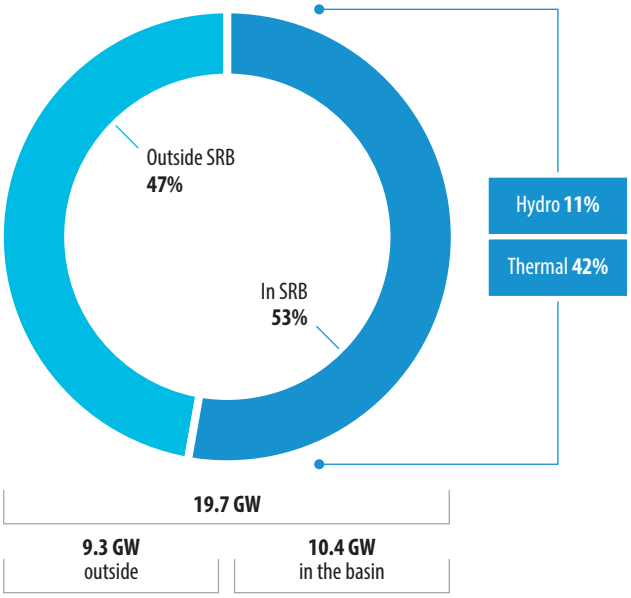


Energy and Water

Most of the region's electricity production takes place in the Sava Basin (see Figure 23). The basin is home to 76 per cent of the region's thermal power plants – which require water resources for cooling -- it is likely that future construction of thermal power plants will also take place in this basin. In addition, the Sava Basin provides the largest proportion of the hydropower generation in the region -- by country this amounts to 15 per cent in Slovenia, 5 per cent in Croatia, 24 per cent in Bosnia and Herzegovina, 31 per cent in Serbia and 45 per cent in Montenegro of national hydropower generation.[154] The basin's large quantities of hydropower (also its further potential) and flexibility of its use can facilitate large penetration of solar and wind power plants in its riparian countries by providing "balancing services" (i.e. storing energy from intermittent renewable sources and then providing energy supply in response to demand peaks). The energy sector in the Sava Basin has proven vulnerable to the status of water resources — in dry spells generation from hydropower plants has decreased, and during flooding instances, cooling systems have been compromised, resulting in forced shut downs. Flooding has also affected operation of coal mines in Serbia.[155] At the same time, energy is used for powering the water system, which includes water pumping, irrigation and treatment.

FIGURE 23
Role of hydropower in the energy mix in the Sava River Basin (SRB)

Installed capacity in the region in 2012



Water and Land

Both built and natural infrastructure provide important flood control services. Maintaining, managing and valuing such services is key to reduce the potentially devastating socio-economic impacts of flood events. Sound land use management and gradually improving flood risk management with the implementation of the EU Floods Directive and the Protocol on Flood Protection to the FASRB[156] are expected to improve the situation. Lower impact floods, which often last for up to four days, can be better contained if natural floodplains are complemented by spare reservoir capacity, and a centennial flood (with levels of about 6,000 m^3/s) hitting the Sava River Basin could be delayed by at least four hours if current water storage infrastructure (with a capacity of 1,752 km^3) are half full.[157] Erosion and sedimentation affect different sectors, notably navigation. The recently completed sediment mass balance study[158] and the Protocol on Sediment Management to FASRB (text signed in July 2015) provide a good basis for developing concerted actions, including regulation of sediment extraction from the river bed.

The links between land, water and energy resources will intensify in the future. Socio-economic developments will drive a more intense use of resources in the Sava Basin. Pressures on land, water and energy resources will increase for all countries. However, not all basin's resources will be affected in the same way. Water resources in particular will experience heavier impacts both from linkages to energy and land resources (see Figure 24). Indirect effects need also to be considered --for example, an expansion in the agro-industry will necessarily result in an increase in irrigation requirements, in turn that will result in energy demand.

[154] Lucia de Strasser and others, Draft report on the water-food-energy-ecosystems-nexus in the Sava River Basin, Royal Institute of Technology, dated 8 April 2015. Available from: http://www.savacommission.org

[155] United Nations Serbia, *Serbia floods 2014* (Belgrade, European Commission and the World Bank Group, 2014). Available from: http://ec.europa.eu/enlargement/pdf/press_corner/floods/20140715-serbia-rna-report.pdf

[156] The text of the Protocol on Flood Protection to FASRB was completed in 2010 and the Protocol has been ratified by all countries.

[157] ICPDR, Preliminary Flood Risk Assessment in the Danube River Basin (Vienna, ICPDR, 2012). The effect of spare storage capacity was calculated by KTH.

[158] ISRBC, Towards Practical Guidance for Sustainable Sediment Management using the Sava River Basin as a Showcase: Estimation of Sediment Balance for the Sava River (Zagreb, ISRBC, 2014).

FIGURE 24
Future trends among nexus linkages in the Sava Basin

BASIN TRENDS

PRECIPITATION	↘
TEMPERATURE	↗
ECOSYSTEM SERVICES	↘
POPULATION	↘
ECONOMY (medium term)	↗

↗ RISE ↗↗ SIGNIFICANT RISE ↘ DROP

BY 2030

NATIONAL TRENDS	SLOVENIA	CROATIA	BOSNIA AND HERZEGOVINA	MONTENEGRO	SERBIA
WATER FOR FOOD & LAND Irrigation needs	↗↗	↗↗	↗	↗	↗↗
WATER FOR ENERGY Electricity generation needs, cooling	↗↗	↗	↗↗	↗	↗↗
ENERGY FOR WATER Treat, move and store water	↗	↗	↗	↗	↗
ENERGY FOR FOOD & LAND Grow, store, process and move food	↗	↗	↗	↗	↘
FOOD & LAND FOR ENERGY Food-energy competition for water, biofuel production	↗	↗	↗	↗	↗
IMPACT OF FOOD & LAND ON WATER RESOURCE Water pollution, agricultural use	↗	↗	↗	↗	↗

Looking at the future, the links between hydropower generation and agricultural production are of particular importance in the Sava Basin. As discussed earlier, economic development will drive the expansion of energy generation and agricultural production. The future implications depend, among other factors, on actions taken to limit impacts on the environment. Hydropower is under pressure to be exploited to a larger extent in the region due to its low cost, being a 'domestic resource', increasing demand and its greenhouse gas reduction potential.[159] At the same time, if developed sustainably —the Guidelines for Sustainable Development of Hydropower in the Danube River Basin provide direction to such efforts — and coherently in relation to other policies, the hydropower capacity can play a key role in the achievement of renewable energy and climate change mitigation targets (Box 13). By taking into account related constraints and other water needs, and with effective transboundary cooperation, this can be done without compromising the other crucial services that water resources provide for the riparian countries.

BOX 13.
Multi-purpose reservoirs and smart management to increase the deployment of renewable energy taking into account diverse needs and constraints in the Sava River Basin

Renewable Energy Sources targets in energy and electricity gross final consumption for 2020

Countries	Overall RES share in 2009	Overall RES share in 2020	Share of RES in the gross final consumption of electricity in 2020
Slovenia	16.2%[a]	25.3%	39.3%
Croatia	12.8%[a]	20.1%	39.0%
Bosnia and Herzegovina	34%	40%	44.0%
Serbia	21.2%	27.0%	36.6%
Montenegro	26.3%	33.0%	51.4%

[a] The figures for Slovenia and Croatia correspond to the year 2005, as that is the reference year of the Europe 2020 target of a 20 percent reduction in GHG emissions.

In the Sava River Basin, each country has set long-term renewable energy targets, have energy security concerns and GHG mitigation goals. Each of these is strongly impacted by current and future hydropower generation in the Sava River Basin. In the case of Slovenia and Croatia, these goals are linked to their status as EU Member States while, for the remainder countries, in the efforts to become member States. In that respect, non-EU Sava River Basin countries are Contracting Parties of the Energy Community, which aims at facilitating the transposition of EU energy policy to non-EU countries from South East Europe and Black Sea region. All riparian countries have developed National Renewable Energy Action Plans for the whole energy sector, which target specific sectors, namely transportation, electricity and heating and cooling.

Hydropower plants linked to dams are characterised by great ramping rates and can be used to integrate other renewables (wind and solar power). When the wind is not blowing or the sun not shining, hydropower can be used to increase generation. This will be key in advancing towards renewable targets (as well as GHG mitigation and energy security targets) responding at the same time to the increasing need of having more flexibility in the energy system.

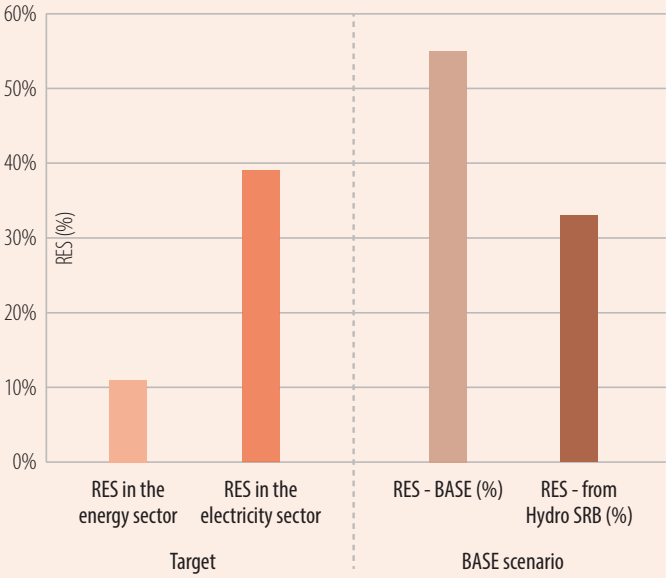
In addition to hydropower, regulating water flows and reservoir levels provides a slew of other services. These include ensuring: appropriate water levels for withdrawals for water supply and irrigation; maintaining appropriate depths for navigation; and providing a buffer for flood control. The use of multi-purpose reservoirs to ensure that short term operational needs are satisfied, while longer term goals are realised will be critical to utilizing the Sava River Basin waters.

The quantification exercise performed in the nexus assessment by the Royal Institute of Technology (KTH) with input from JRC indicates that, taking the Sava River Basin countries as a whole, the RES targets are within reach and can even se surpassed, reaching 55 per cent in 2020, as it is illustrated in the figure.

Hydropower plants located in the Sava River basin play a decisive role in meeting the renewable energy targets. Taking the results from the baseline scenario, the electricity generation from hydropower using waters of the Sava River could represent 33 per cent of the total contribution of the renewable energy sources.

In light of such renewable energy generation opportunities, transboundary cooperation between Sava countries can therefore prove to be advantageous in providing energy security, decreasing energy dependency and contribute to the decarbonisation of the energy system. Also, cooperation can be crucial when competing uses of water have to prioritised, taking into account needs for agriculture and public supply, for example. Moreover, from the energy production side, hydropower and thermal production could be easily complemented if operation of these technologies is compromised during drier years due to water shortage or increase in electricity load due to cooling requirements, which can affect countries differently, but could be buffered by cooperation agreements.

Renewable Energy Sources (RES) contribution to the electricity generation in the Sava River Basin (SRB) region in the baseline scenario[b]



[b] In the baseline scenario, historical flow data for the period from 2003 to 2013 was used to estimate the capacity factors of 25 selected hydropower plants in the Sava River Basin. These values were then transposed to the remaining hydropower plants in the Sava River Basin (in operation, construction or planned) in accordance to criteria of proximity and upstream-downstream location along the Sava River and its tributaries. As for the hydropower plants located outside the Sava River Basin, average capacity factors were assumed to be similar.

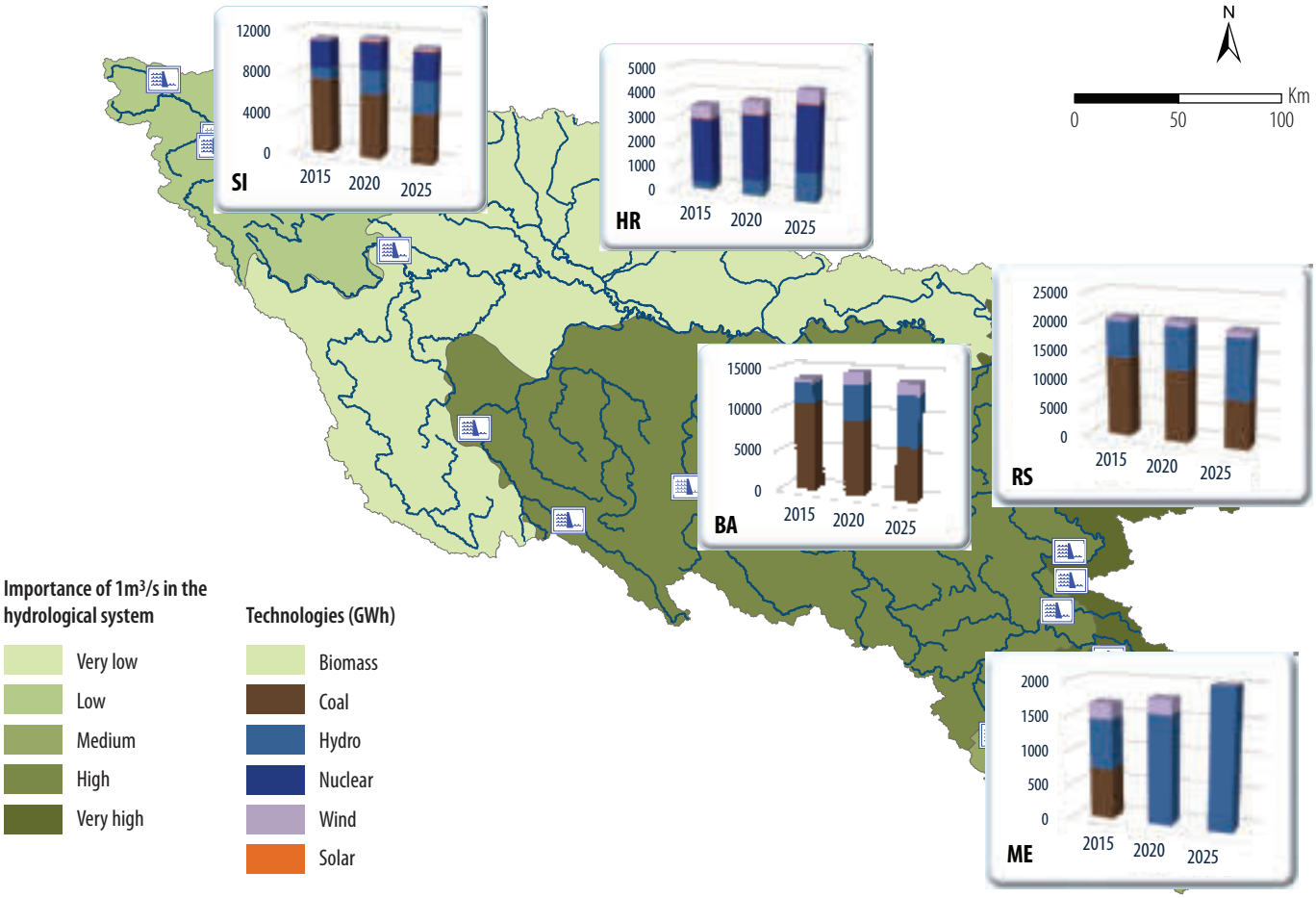
Source: Lucia de Strasser and others. Draft report on the water-food-energy-ecosystems-nexus in the Sava River Basin, Royal Institute of Technology, dated 8 April 2015. Available from http:// www.savacommission.org

[159] The actual hydropower generation capacity in the Sava Basin is 2,188 (MW), while some 3,358 (MW) is planned. For details and the various sources, the following document can be referred to: Lucia de Strasser and others. Draft report on the water-food-energy-ecosystems-nexus in the Sava River Basin, Royal Institute of Technology, dated 8 April 2015. Available from http://www.savacommission.org

Both hydropower development and agricultural development are heavily dependent on water resources, which will be affected by climate change as well as by land use change. The results of the analysis of the combined effects of hydropower and agricultural expansion are described briefly here, illustrated with three figures. Future hydropower expansion was modelled assuming that the energy sector minimises the generation costs of the energy mix and typical business as usual expectations. Hydropower expansion was modelled under two scenarios developed. The first scenario assumes a drier climate (i.e. lower rainfall) according to the Intergovernmental Panel on Climate Change (IPCC) projection RCP45.[160] The second scenario adds to the first scenario the cumulative effect of agricultural expansion (which generates an increase in water demand for agricultural uses). The detailed integrated hydrological model LISFLOOD with embedded irrigation requirements was used by JRC to calculate the water availability for hydropower as a consequence of increased irrigation and climatic change effects with the generation mix under the baseline scenario (figure 25).

The changes in electricity generation mixes under the two scenarios have knock-on effects on energy trade (net electricity imports) as well as greenhouse gas emissions (emissions of carbon dioxide, CO_2). Figures 26 and 27 show the results for Bosnia and Herzegovina. Figure 26 shows the changes in energy trade levels: as water is diverted for crop production, the amount of electricity that would need to be imported also increases. Under the second scenario, agriculture expansion exacerbates the increased irrigation needs prompted by lower rainfall. As shown in figure 27, greenhouse gas emissions trajectories change as well – lower hydropower production results in higher emissions for both scenarios.

FIGURE 25
The energy generation mix in five Sava Basin riparian countries according to the baseline scenario



[160] Representative Concentration Pathways (RCPs) are consistent sets of projections about radiation serving as input for climate modelling.

FIGURE 26
Modelled changes on water availability for hydropower in Bosnia and Herzegovina and consequently on energy imports under a drier climate scenario

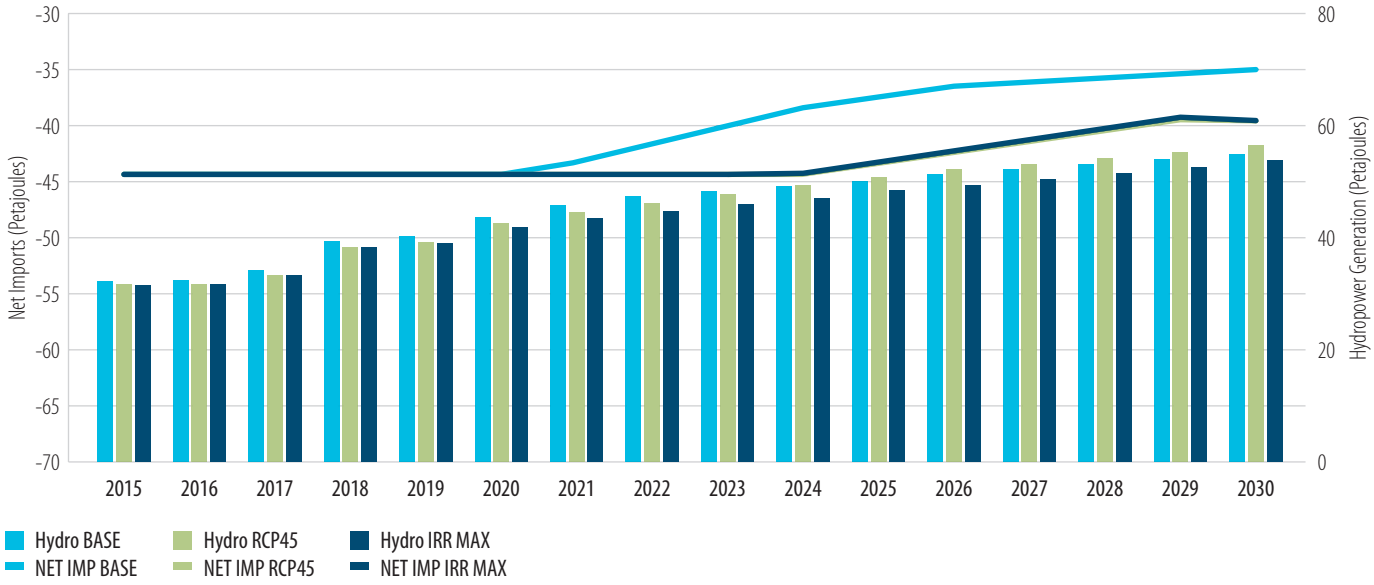
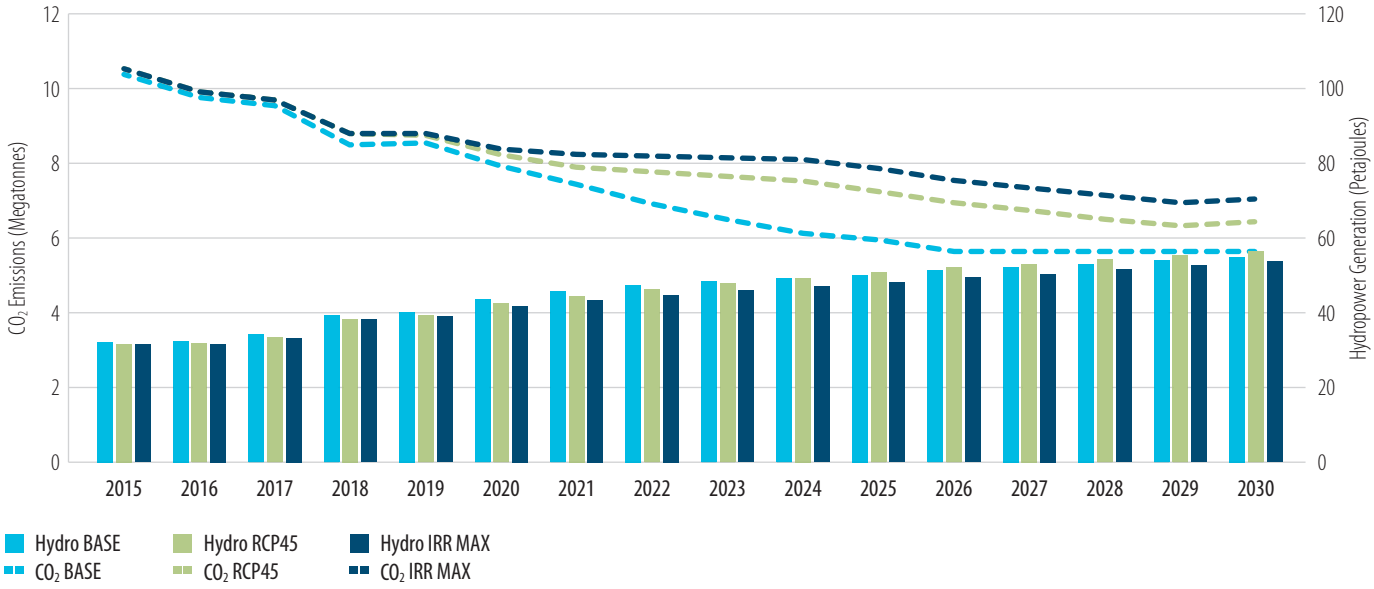


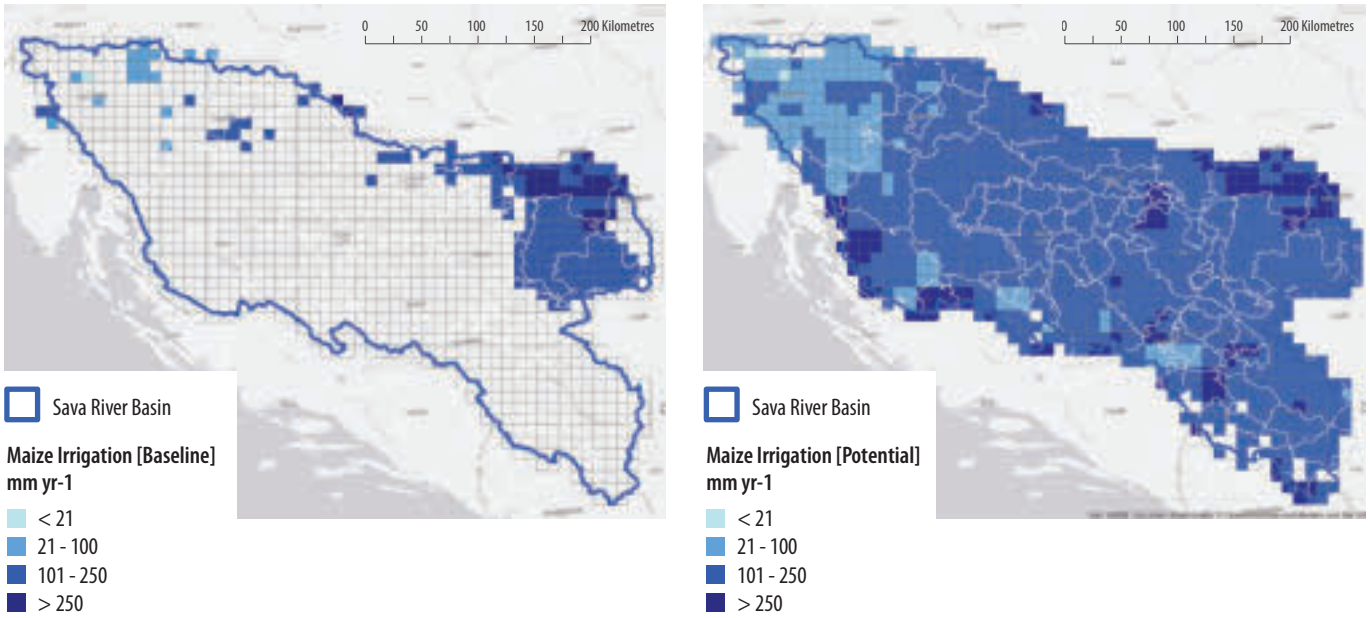
FIGURE 27
Modelled changes on water availability for hydropower in Bosnia and Herzegovina and consequently on CO_2 emissions under a drier climate with expanded irrigation



The detailed hydro-economic modelling, carried out by the JRC as a contribution to the Sava nexus study assessment allowed for analysing effects of optimizing irrigation. The modelling was done by taking into account hydropower facilities and irrigation demands amongst others (LISFLOOD), in combination with a detailed crop growth model (Environmental Policy Integrated Climate [EPIC] model). For the Sava it was found that the current average maize yield of 5.7 tons/ha/year could be increased to 9.9 tons/ha/year - a 74 per cent increase – if maize would be optimally irrigated everywhere in the Sava. This would however have a substantial additional water demand (see figure), of around 200–300 mm for the newly irrigated areas.[161]

[161] de Roo and others. *Modelling the Water–Food–Energy Nexus for scenarios of current and future land use and climate in the Sava River Basin*. Report of the JRC. (Ispra, JRC, forthcoming).

FIGURE 28
Annual Water Demand for current (left) and the optimum maize irrigation scenario (source: JRC 2014)



Such additional water abstractions would then have implications for water available for hydropower and cooling thermal power stations. In addition, the JRC modelling shows that substantial increase in lowflow conditions would arise in the lower Sava – having consequences for navigation, environment, drinking water intake, and further downstream Danube water availability – as well as leading to unsustainable groundwater resources use in the lower Sava region. Additional climate simulations are still ongoing to evaluate additional effects due to climate change.[162]

This analysis highlighted the benefits of efficient irrigation. As agriculture expands more groundwater is pumped for irrigation, which causes an increase in energy use for pumping -- due to both increased quantity of water to be extracted and to the increased depth from which water has to be pumped. Moving to efficient irrigation would reduce the total volume of water that needs to be pumped, thus reducing energy demand. Reductions in water used lead to other effects -- such as reduced water logging and salinization. In dry years, electricity production costs increase due to lower hydropower generation -- which needs to be compensated by generating additional power generated in thermal power plants and increasing electricity imports from nearby countries (with energy systems that will likely be facing similar pressures). These are the years when irrigation levels will increase, and when the cost of irrigation will increase (due to higher energy costs and the need to pump water from deeper levels). Thus, increased water efficiency in irrigation has the benefit of reducing water consumption, with a more pronounced effect when water is scarcest.

The analysis also highlighted the need for aligning timescales of energy and water planning. Energy planning (including the assessment of energy expansion needs, the setting of renewable energy targets, the definition of energy efficiency policies, and other energy planning aspects) usually takes a multi-decadal perspective. This is also the case for climate policies – when projecting greenhouse gas emissions trajectories, and developing mitigation and adaptation strategies. However, water resources management planning (driven by the implementation schedule of the EU Water Framework Directive) mostly follows a six-year cycle.

As a consequence, long-term energy planning does not necessarily take into account water constraints, potentially putting long-term investments and policy targets at risk. Obviously the degree to which different sectoral planning processes take other sectors and resource constraints into account depends heavily on governance.

[162] The average annual rainfall over the Sava River Basin is estimated to be approximately 1,100 mm. The average evapotranspiration for the whole catchment area is approx. 530 mm/year. *Source:* Sava River Basin Management Plan, ISRBC, 2014.

EXPLORING SOLUTIONS

In response to the intersectoral challenges described earlier, several types of responses can be helpful.

Institutions. While the Sava Basin already has a relatively well-developed governance architecture, it can be further improved to apply a nexus approach. Options to strengthen it include:

- **Clarifying roles and responsibilities** – two important areas are (i) monitoring of basin resources and (ii) supporting the application of sustainable development principles in economic and sectoral planning and decision-making.
- **Developing a consultation process** to review the impacts of national and sectoral development strategies on basin resources – for basin-level impacts this could be done through the International Sava River Basin Commission.
- **Reviewing the mandate** of the International Sava River Basin Commission, which already serves as a platform for navigation and water management issues to be able to discuss (and eventually act) regarding all relevant basin resources.[163]

Information. The implementation of a nexus approach to managing the Sava Basin's resources requires better information to improve national-level inter-sectoral coordination and the development of a shared knowledge base for transboundary cooperation. Options include:

- **Monitoring** of basin resources (groundwater, surface waters, biodiversity, soil, sediment, land use) both in terms of quantity and quality, and with particular attention to some degradation processes (e.g. erosion and sedimentation).
- **Forecasting,** in particular of water-related hazards (floods and droughts) in order to reduce related risks, and projecting demands to support planning.
- **Improving access and sharing of information,** for example through further development of the International Sava River Basin Commission database[164] and improving the online accessibility of environmental information and data.
- **Guidelines** which synthesize good experience and help to harmonize approaches. Examples include (i) the Guiding Principles for Development of Inland Navigation and Environmental Protection in the Danube River Basin; (ii) the Guidelines for Sustainable Development of Hydropower in the Danube River Basin, and (iii) Transboundary Eco-tourism Guidelines for the Sava River Basin. With the various guidelines available, emphasis should be on applying the principles and putting them into practice.

Instruments. There is scope for a more systematic use of policy instruments to address the trade-offs and exploit the synergies offered by a nexus approach to managing the Sava Basin's resources. A mix of policy instruments will be needed to exploit the high potential in the basin to increase resource efficiency – for example by promoting the use of low flow appliances in households, and water and energy efficient technologies, industries and utilities, and the adoption of more efficient irrigation practices. Options include:

- **Regulatory instruments,** such as
  - Transboundary Environmental Impact Assessment (for projects)
  - Strategic Environmental Assessment (for plans and programmes)
  - Minimum environmental flows (regulated by law)
- **Economic instruments,** which can serve both to provide behaviour-altering incentives (positive or negative) and to raise funds.
- **Information instruments,** in particular guidance and training of productive agents (such as utility operators, farmers), but also including awareness of users and consumers (for example regarding water and energy use).

[163] The Parties to the FASRB are considering amendments to FASRB introducing the legally binding character of the ISRBC decisions to certain fields of water management. This is already the nature of ISRBC of decisions related to navigation.

[164] Establishment of the core Sava geographical information system (GIS) functionalities and completion of the Sava hydrological information system will improve sharing of information.

BOX 14.
Use of Strategic Environmental Assessment in the Sava countries

Strategic Environmental Assessment (SEA) is an instrument with great potential for resolving conflicting demands on water usage and can be used for policy-level assessments with multi-sectoral impacts, for example in order to conduct assessments with relevance to the Habitats Directive. While laws on Environmental Impact Assessment (EIA) and SEA have been introduced at the framework level throughout the region, in some riparian countries implementation is not complete and practice is not well developed. Only 70 EIAs had been conducted in Republika Srpska by 2010, for example, mostly related to extractive industries and energy production. The applicability of strategic environmental assessment, or SEA, of public plans and programmes is less uniform throughout the region. The EU SEA Directive 2001/42/EC has been transposed into the legislation of Member States Slovenia and Croatia, while harmonization of legislation is advanced in Serbia but not beyond an initial stage in Bosnia and Herzegovina. Most transboundary SEAs conducted in the region are related to water management and energy.

Main sources: UNECE, 2nd Environmental Performance Review of Croatia, 2014; UNECE, 3rd Environmental Performance Review of Serbia, 2015; RENA, 2012. Regional Environmental Network for Accession (RENA). Working Group 4, Activity 4.2. Country External Assessment Reports: Bosnia and Herzegovina.

Infrastructure. The sustainable management of the Sava Basin's resources will require larger but also smarter investment in infrastructure as well as consultation of different related interests and assessment of impacts. For example, multi-functional reservoirs and synchronised reservoir control can provide a buffer, strategic releases and flow control. There is also unquantified but important potential for natural infrastructure. Options include:

- **Promoting multiple and flexible use of infrastructure** – in particular dams, irrigation and drainage systems.
- **Investing in expanding and upgrading water infrastructure** – such as wastewater treatment.
- **Coordinating infrastructure investments** – such as in hydropower and other renewable energy sources.
- **Protecting natural infrastructure assets** – such as floodplains and wetlands.

International coordination and cooperation. While a large part of the possible actions detailed above can rely on national-level actions, international coordination and cooperation at basin and regional level offers additional opportunities to "manage the nexus". Examples include:

- **Legal instruments** – in particular the FASRB and its protocols (Protocol on Flood Protection, Protocol on Sediment Management, Protocol on Prevention of Water Pollution caused by Navigation, Protocol on Emergency Situations) but also including the EU Directives (Water Framework Directive, Flood Directive).
- **Transboundary planning processes** – such as the Sava River Basin Management Plan (to coordinate action between different water using sectors, energy and agricultural sectors) and the Flood Risk Management Plan for the Sava River Basin (to coordinate action around flood retention areas and wetlands).
- **Regional integration and harmonization.** Among the Sava River Basin countries, the EU accession and approximation provide a common driver and have already played an important role in calling for the integration of policies and supporting investments in water management and beyond. These processes introduce a level of harmonization gradually to the legal bases. The EU common market also lead into harmonization of rules and application of common standards.

BOX 15.
Funding infrastructure solutions in the Sava countries

The principle of cost recovery is important to balance water use in many sectors like agriculture, industry, energy, and public services (households) to achieve cost-efficiency and even to establish cross-sectoral cooperation among providers and consumers of water services.

For funding the necessary infrastructure upgrades and extensions, various possible actions have been highlighted to the Sava riparian countries, for example by UNECE in the Environmental Performance Reviews:

- **ensuring the financial viability of utility companies and internalising externalities by gradually raising the tariffs to levels that allow for a full cost recovery and reflect the real supply costs and increasing bill collection rates (Montenegro, Serbia);**
- **regionalizing communal utility services to exploit the scope for public-private partnerships in the provision of services (Montenegro);**
- **introduce individual metering of water consumption (Serbia);**
- **establishment of autonomous institutions operating on a financially sustainable basis and of an independent body to regulate prices and benchmark utility performance (Slovenia)**
- **introduce secondary legislation with an unambiguous fee structure and initiate collection of all fees and charges instituted by it (Bosnia and Herzegovina).**

Sources: UNECE, Environmental Performance Reviews (EPR) of Bosnia and Herzegovina (2nd EPR), 2011; Croatia (2nd EPR), 2014; Montenegro (3rd); and Serbia (3rd EPR), 2015; OECD, Environmental Performance Review of Slovenia, 2012.

IDENTIFYING THE BENEFITS OF ADOPTING A NEXUS APPROACH

By adopting a nexus approach to the management of the Sava Basin's resources, Sava countries can exploit many potential benefits. The results of a rapid scoping of those benefits is summarised in Table 16. Table 16 follows the analytical framework for analysing the benefits of transboundary water cooperation developed according to the UNECE's policy guidance note on identifying, assessing and communicating the benefits of transboundary water cooperation.[165]

All the benefits of adopting a nexus approach to the management of basin resources are ultimately enjoyed by individual countries. In some cases, the benefits are only enjoyed by the country that takes action. In many cases, however, the actions of one country generate benefits in other countries (transboundary dimension). When potential individual solutions are evaluated ex-ante, it may be possible to identify and to some extent assess which benefits are enjoyed nationally and which ones are enjoyed by other countries. However, considering the aggregated benefits of a package of potential measures would justify more ambitious action than would be the case if each measure is evaluated only individually.

TABLE 16
The benefits of transboundary cooperation on the nexus issues in the management of the Sava Basin's resources

	On economic activities	Beyond economic activities
From improved management of basin resources	**Economic benefits** • Increased viability of economic activities relying on basin resources • Development of agricultural sector and its value added • Development of sustainable river tourism • Reduced economic costs of water-related hazards (floods and droughts) • Reduction of transport costs or increased volume of traffic (thanks to increased capacity and use of better maintained waterways) • Reduction of energy costs (thanks to optimisation of potential energy sources) • Reduction of water infrastructure costs (thanks to avoidance of duplication and sub-optimal location)	**Social and environmental benefits** • Employment creation (e.g. in agriculture and tourism sectors) • Reduced human costs of water-related hazards (e.g. floods) • Health benefits from improved water quality • Improved water services for users • Improved recreational opportunities from improved water quality and healthier ecosystems
From increased trust among Sava countries	**Regional economic cooperation benefits** • Increased trade through waterways • Development of regional markets for goods, services and labour • Increased cross-border investments	**Geo-political benefits** • Improved likelihood of complying with EU requirements and regional targets (e.g. regarding status of waters, renewable energy targets and agricultural policy)

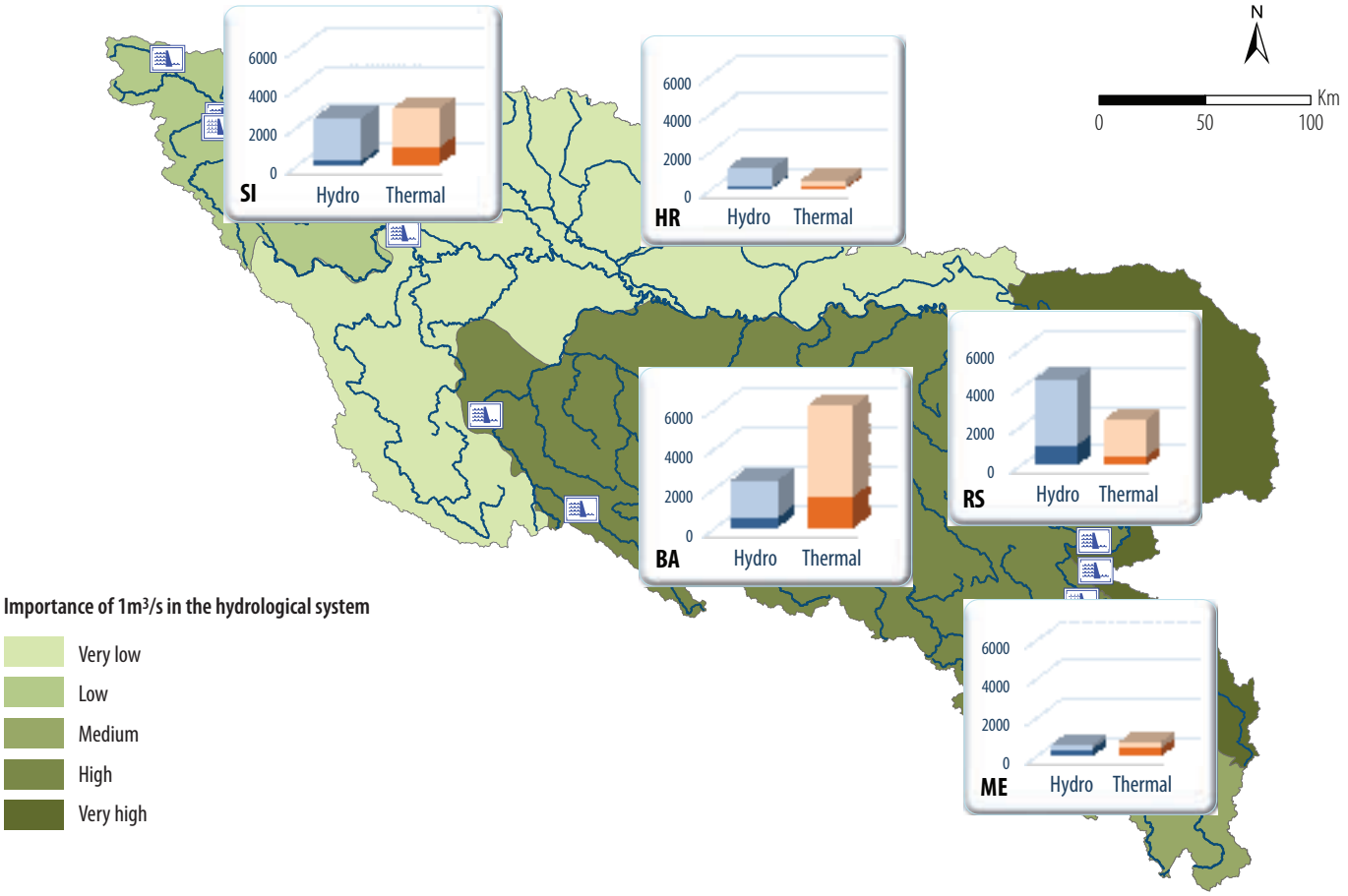
[165] UNECE, Policy Guidance Note on the Benefits of Transboundary Water Cooperation: Identification, Assessment and Communication (New York and Geneva, United Nations, 2015).

Adopting a nexus approach under transboundary cooperation would allow maximising the potential benefits provided by the basin's resources. For example, it would allow using water in the sector and location where it provides the highest value. The value of water varies across the basin. Figure 29 shows how "upstream water" has a high value as it can pass through more hydropower plants. As a consequence, from an overall systems perspective, investments in irrigation efficiency become economically attractive also in upstream parts of the river basin even if conditions for agriculture are more favourable downstream.

FIGURE 29

Indicative value of water use for hydropower and planned power plant expansions in the Sava Basin

The figure shows the importance of the impact (in terms of additional costs and GHG emissions) of removing 1 m^3/s of water from the hydrological system currently feeding the electricity generation system of five riparian countries in the Sava Basin if, instead, the same amount of electricity had to be generated from other sources. Also, the capacities of the existing and planned thermal and hydropower plants in each country are shown as bar charts on the map (MW, with existing capacity in the darker shade).



CONCLUSIONS AND RECOMMENDATIONS

The Sava Basin's resources play a key role in the development in each riparian country. As it has been discussed above, energy, water, land and environmental resources in the Sava Basin contribute to economic development and employment generation, and they have the potential to increase that contribution to developments in resource-based sectors such as agriculture/agro-industry and tourism.

The basin's resources are under increasing pressures. Growing demand for energy is driving the expansion of energy system investments, which are closely linked with water availability. Growing water demands from several sectors often go together with decreasing water availability under climate change. Land use changes driven by socio-economic factors and climate change will exacerbate the impact of flood risks and water scarcity.

Most links between countries and sectors in the basin take place through water resources. The Sava Basin's water resources are central to electricity development in the region -- by 2030 approximately 30 per cent of new thermal power plants and 19 per cent of new hydropower plants of all riparian countries are expected to rely on the water resources of the Sava Basin. Flood control will continue to be important to avoid power generation failures due to malfunctioning of thermal cooling systems – especially as new power plants are built in downstream countries. The impacts of climate change will be felt in the energy and agricultural sectors through changes in the availability of water resources. Controlling erosion and sedimentation would benefit agriculture, land management, extractive industries, navigation and water resources. Water resources need to be managed to meet direct and indirect (nexus) needs at all times – including through minimum flow requirements.

From the perspective of hydropower generation, water upstream is of higher cumulative value than water downstream as it can be used for hydropower generation in more power plants than water further downstream. The notion of water value across the basin can inform the prioritisation of actions.

The trade-off between hydropower development and agricultural expansion needs to be carefully managed. Hydropower investments in the Sava Basin are key to achieving climate change mitigation targets in the region (by 2030, 43 per cent of carbon dioxide reductions in the riparian countries is expected to come from hydropower investments) as well as to national renewable energy targets (between 10-36 per cent of depending on the country). The modelling results suggest that significant crop yield increases could be obtained by optimising irrigation. However, increased irrigation might have substantial effects to surface water and groundwater flow, especially in the lower Sava Basin during dry periods. Expected higher levels of irrigation would reduce water availability for hydropower generation some of the tributaries — increasing energy costs and greenhouse gas emissions.

The strong demand for hydropower provides the opportunity to invest in multi-functional infrastructure or to adopt designs that minimise impact on the environment. Approximately 200 MW of hydropower generation will be built in the region with reservoirs. These reservoirs may help serve as flood control, maintaining appropriate navigation depths and rationalising investments and maximising the utility to be had from the water. Irrigation and drainage systems' development could be done taking into account effects on flood response.

Responding to the challenges and seizing the opportunities requires stronger multi-sector and transboundary planning. Measures addressing single challenges in individual sectors a single cannot be taken any longer in isolation. They need to be evaluated in a multi-sectorial environment in order to recognise and manage the trade-offs – for example, building hydropower dams for energy targets and dykes for flood protection might conflict with EU Water Framework Directive aims such as hydro-morphology and ecological status. The linkages between sectors and countries, as well as the broader social and economic impacts, need to be recognised and better understood in order to prioritise actions in the different countries and sectors. Planning across sectors needs to be better aligned in terms of timescales – currently, the energy sector is defining investment plans with decades of anticipation while river basin management plans have six-year horizons. Consultation on national and sectoral development strategies through ISRBC, taking into account basin-level impacts, would be beneficial to that end. At the same time, differences in governance frameworks for different sectors or uses need to be acknowledged and taken into account.

Preparation of River Basin Management Plans supports **valuable engagement with a broad range of stakeholders at the transboundary level but improving coordination with energy and agriculture sectors would be an important reinforcement** to its scope. The strategic environmental assessment (SEA) is an effective tool to assess the impact of energy, water management and agricultural programmes and policies on ecosystems and to synchronize competing objectives, as well as to ensure proper public participation.

The Sava Basin already has in place a multi-sectoral platform for transboundary cooperation. The International Sava River Basin Commission allows for different interests to be heard when issues of concern related to use and protection of water resources are being discussed. It facilitates the harmonization of approaches, application of jointly developed guidelines and principles – for sustainable hydropower, navigation and environmental protection. EU policies and processes represent both a driver and an opportunity to improve management of the nexus – for example the EU initiative to improve resource efficiency beyond sectoral mandates.

More intense transboundary cooperation on the management of basin resources will bring additional real benefits. This does not apply just to transboundary water cooperation. For example, the different energy generation and storage capacities make up valuable complementarities which can add to the energy security for all the riparian countries.

Ultimately, stronger and more coherent national policies, based on reliable information covering different sectors, are needed to "manage the nexus". They are needed, for example, to resolve existing water allocation conflicts. Multi-sectoral assessment processes, such as Strategic Environmental Assessment including, can support the development of more coherent national policies. Development of broad, open, transparent and efficient platforms for reliable, high-quality data to serve as the foundation for high-quality decision-making merits focused efforts. Supporting and up-grading the currently uneven monitoring capacities would improve inputs.

This nexus assessment only provides an overview of the importance of the basin's resources, the inter-sectoral linkages, potential solutions and untapped benefits. Further analytical, stakeholder engagement and planning work will be needed to identify precise governance reforms, policy measures and investment opportunities to address the challenges and seize the opportunities.

CHAPTER 7

Summary of the assessment of the water-food-energy-ecosystems nexus in the Syr Darya Basin

INTRODUCTION

AIM, OBJECTIVES AND SCOPE

The nexus assessment of the Syr Darya Basin aims to support national policy development and transboundary cooperation among the Syr Darya Basin countries in the sectors of water, energy, food and environmental policies by strengthening the knowledge base for integrated policy development and decision-making.

The specific objectives of this nexus assessment are:

(a) to provide a picture of the status and trends of resource needs and the environmental impact of the main economic activities in the basin;

(b) to identify the main intersectoral challenges that call for integrated – or at least coordinated – planning and management involving different sectors, as well as transboundary cooperation;

(c) to identify current opportunities to improve resource efficiency, reduce negative impacts across sectors and/or countries, and increase sustainability with an emphasis on practical, mutually-beneficial opportunities.

The assessment also follows up and builds on the study "Strengthening cooperation for rational and efficient use of water and energy resources in Central Asia" developed within the framework of the United Nations Special Programme for the Economies of Central Asia (SPECA) in 2004.

The scope of this nexus assessment is limited to providing a preliminary overview of the relevant issues, while exploring some potential solutions. This preliminary, largely qualitative analysis can serve as the basis for more detailed analyses.

ASSESSMENT PROCESS

The original proposal from the Scientific-Information Center (SIC) of the Interstate Coordination Water Commission (ICWC) of the Central Asia and the Global Water Partnership (GWP) Caucasus and Central Asia was to carry out a nexus assessment of the Aral Sea Basin, but it was later decided to carry out a downscaled variant focusing on the Syr Darya.

This assessment follows the methodology developed by UNECE, which includes:

(a) a desk study to review and analyse relevant documentation (resource base and resource uses, socioeconomic situation, governance and policy framework);

(b) a participatory workshop jointly organized in Almaty (Kazakhstan) on 2–4 December 2014 by the UNECE and the GWP, in close cooperation with the Food and Agriculture Organization of the United Nations (FAO). Representatives of various ministries (natural resources, agriculture, energy and environment) from Kazakhstan, Kyrgyzstan and Tajikistan, and regional organizations based in Uzbekistan,[166] as well as NGOs and academia participated;

(c) drafting the assessment based on the findings of the desk study and the workshop, complemented with an analysis of the jointly identified issues; and

(d) incorporation of inputs from local experts and officials of the Syr Darya countries provided in the framework of the third meeting of the Task Force on the Water-Food-Energy-Ecosystems Nexus (Geneva, 28–29 April 2015), as well as complementary consultations held in the first half of 2015 in Kazakhstan, Kyrgyzstan and Tajikistan, linked to the European Union Water Initiative's National Policy Dialogues on IWRM.

[166] It should be noted that Uzbekistan does not associate itself with the nexus assessment of the Syr Darya.

BASIN OVERVIEW

Water resources

The Syr Darya is the longest river in Central Asia (3,019 km from the headwaters of the Naryn) and the second largest (after the Amu Darya) in terms of water quantity (annual average runoff of 36.57 km^3).[167] It is shared by Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan. Its hydrological basin forms, together with the Amu Darya, the main water resource system of Central Asia: the Aral Sea Basin. The basin of the Syr Darya can be divided into: 1) the upper reaches, consisting of the Naryn and the Kara Darya tributaries and the Fergana Valley; 2) the middle reaches; 3) the sub-basins of the Chirchik, Ahangarana and Keles; and 4) the lower reaches.[168]

The flow of the river is mainly fed by glacier and snowmelt and is therefore highly variable both seasonally and between years. The extremes include dry years (characterized by droughts) and high-flow years (characterized by floods),[169] with both extremes damaging for the economy in the basin.[170] The operation schedule of the reservoirs on the Naryn river (a major tributary located in Kyrgyzstan and Uzbekistan), in particular the Toktogul reservoir in Kyrgyzstan, is critical for the provision of water to the large irrigation schemes downstream (to the Fergana Valley and further downstream in Uzbekistan and Kazakhstan), as well as for electricity production upstream, mainly in Kyrgyzstan. Some 90 per cent of the Syr Darya's mean annual flow is regulated by reservoirs. Most reservoirs are used mainly for irrigation and flood control.

Land resources

The basin area is characterized by mountains in the east and flat areas with decreasing altitudes going towards north-west. Its main geomorphologic features are the Alpine ranges of Tien Shan (over 5,000 m of altitude, located in Kyrgyzstan), the Fergana Valley (an alpine depression at 250–500 m of altitude, shared by Kyrgyzstan, Tajikistan and Uzbekistan), the lowlands of Golodnaya Steppe (shared by Uzbekistan and Kazakhstan, and some territories of North Tajikistan), and the Kyzyl-Kum desert downstream in Kazakhstan.[171]

Half of the agricultural land is found in naturally drained oases while the other half is the result of reclamation projects (that is, drainage, land levelling and improvements of the soil structure), which can be expensive in terms of construction and maintenance. Kazakhstan has good availability of agricultural land, while Kyrgyzstan and Tajikistan, together with some parts of Uzbekistan, have less ample land resources.[172] Land is not only used for crop production but also largely for pasture. Land degradation (that is, loss of humus or soil quality degradation as a result of salinization) is severe in the basin, undermining the long-term productivity of agriculture.

Energy resources

Some of the world's largest oil, coal and natural gas reserves are found in Kazakhstan and Uzbekistan. Existing and planned pipelines cross the basin deliver fossil fuels from Turkmenistan, Uzbekistan and Kazakhstan to the Russian Federation and China. Hydropower contributes to the energy mix in all basin countries but it is much more important for the economies of Kyrgyzstan and Tajikistan. Thermal power plants are fuelled with coal and natural gas and constitute the main electricity production for Uzbekistan and Kazakhstan. The Central Asian Power System (CAPS), the regional electricity grid, connects all the countries in the basin but it is presently not fully functional.[173] High voltage transmission lines are being planned or developed to export electricity produced in Kyrgyzstan and Tajikistan to South Asia through Afghanistan and Pakistan (CASA 1000 Project) and to China.[174] These new connections allow for selling surplus energy outside the region for example in the summer time when demand in the riparian countries is lower and the river flow providing for power generation is greater.

Ecosystems

The status of the environment in the Aral Sea Basin, including the Syr Darya Basin, has suffered degradation since the 1960s. The decreased and seasonally changed water flow has impacted ecosystems (and habitats) in many areas along the river and the rare riparian forest cover is decreasing.[175] However, due to winter flooding, there are also examples of new sites with rich biodiversity such as the Ramsar Site, Aydar-Arnasay. Construction of the Kok-Aral Dam (completed in 2005) in Kazakhstan has raised and stabilized the water level in the North Aral Sea. The revival of fish populations and the fishing industry is another positive effect.[176]

Socioeconomics

The population of the basin exceeds 24 million people. Its distribution by country is presented in table 17. More than half of the population is concentrated in the Fergana Valley, the most important agricultural area in the basin.[177] Large parts of the population are either working in the agricultural sector or are dependent on subsistence agriculture. Despite a significant improvement in the region in the past 15 years, poverty is still widespread in Kyrgyzstan and Tajikistan.[178] The rural population tends to be the poorest in these areas and may have limited access to safe water resources, sanitation facilities, clean and constant energy supplies and food. Severe power cuts and unaffordable food prices in the period 2007–2010 brought entire communities to a state of emergency (particularly in Kyrgyzstan and Tajikistan) due to a combination of low water levels in the reservoirs, cold winters, volatile food prices and the global economic crisis.[179]

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167 FAO, *Aral Sea Basin, AQUASTAT database*, 2012. Available from: www.fao.org/nr/water/aquastat/basins/aral-sea/index.stm

168 The Chu and the Talas rivers are a transboundary sub-basin (Kazakhstan and Kyrgyzstan) of the Syr Darya, but these rivers have lost connection to the main stream of Syr Darya. For this reason, the Chu-Talas basins are not taken into account in this assessment.

169 Note that the flow of the Syr Darya is highly regulated and many reservoirs are used for flood protection. The most flood-prone area of the basin in Kazakhstan is now further protected by the recently built Koksarai dam (2011), which acts as a counter-regulator.

170 UNECE, Strengthening Water Management and Transboundary Water Cooperation in Central Asia: the role of UNECE Environmental conventions. (New York and Geneva, United Nations, 2011) Available from: www.unece.org/fileadmin/DAM/env/water/publications/documents/Water_Management_En.pdf

171 Oxana S. Savoskul and others. Water, Climate, Food, and Environment in the Syr Darya Basin, Contribution to the project ADAPT: Adaptation strategies to changing environments. An adaptation framework for river basins. (Institute of Environmental Studies of Amsterdam, 2003) Available from: www.weap21.org/downloads/adaptsyrdarya.pdf

172 FAO, The Status and Challenges of Food Security in Central Asia (Budapest, April 2011).

173 Due to Uzbekistan's withdrawal from the CAPS network, Tajikistan can no longer import electricity from Uzbekistan or Turkmenistan that transits through Uzbekistan. *Source:* In-Depth Energy Efficiency Review: Tajikistan. Energy Charter Secretariat (2013).

174 Chen Yang and Liang Fei, Regional grid connection planned. In *Global Times*. (2014) Available from: www.globaltimes.cn/content/891105.shtml

175 Ramsar Convention, *Ramsar Convention Guidelines for wetlands in Central Asia*. (Gland, Ramsar Convention Secretariat, 2012) [in Russian].

176 UNECE. *Second Assessment of Transboundary Rivers, Lakes and Groundwaters* (New York and Geneva, United Nations, 2011). Kazakhstan plans to continue from 2015 to 2020 in the first phase of the North Aral Sea project carried out in cooperation with the World Bank.

177 Karen Frenken, ed. Irrigation in Central Asia in Figures. AQUASTAT Survey 2012. In *FAO Water Reports 39*. (Rome, FAO, 2012) Available from: www.fao.org/docrep/018/i3289e/i3289e.pdf

178 *World Development Indicators of the World Bank; FAO Irrigation;* Karen Frenken, ed. (2012).

179 UNDP, *Central Asia Regional Risk Assessment: Responding to Water, Energy, and Food Insecurity*. (New York, UNDP, Regional Bureau for Europe and CIS, 2009).

FIGURE 30
THE SYR DARYA BASIN

Distribution of selected elements relevant to the nexus: water bodies, irrigated areas, power plants; water withdrawals for agriculture; and water supply.

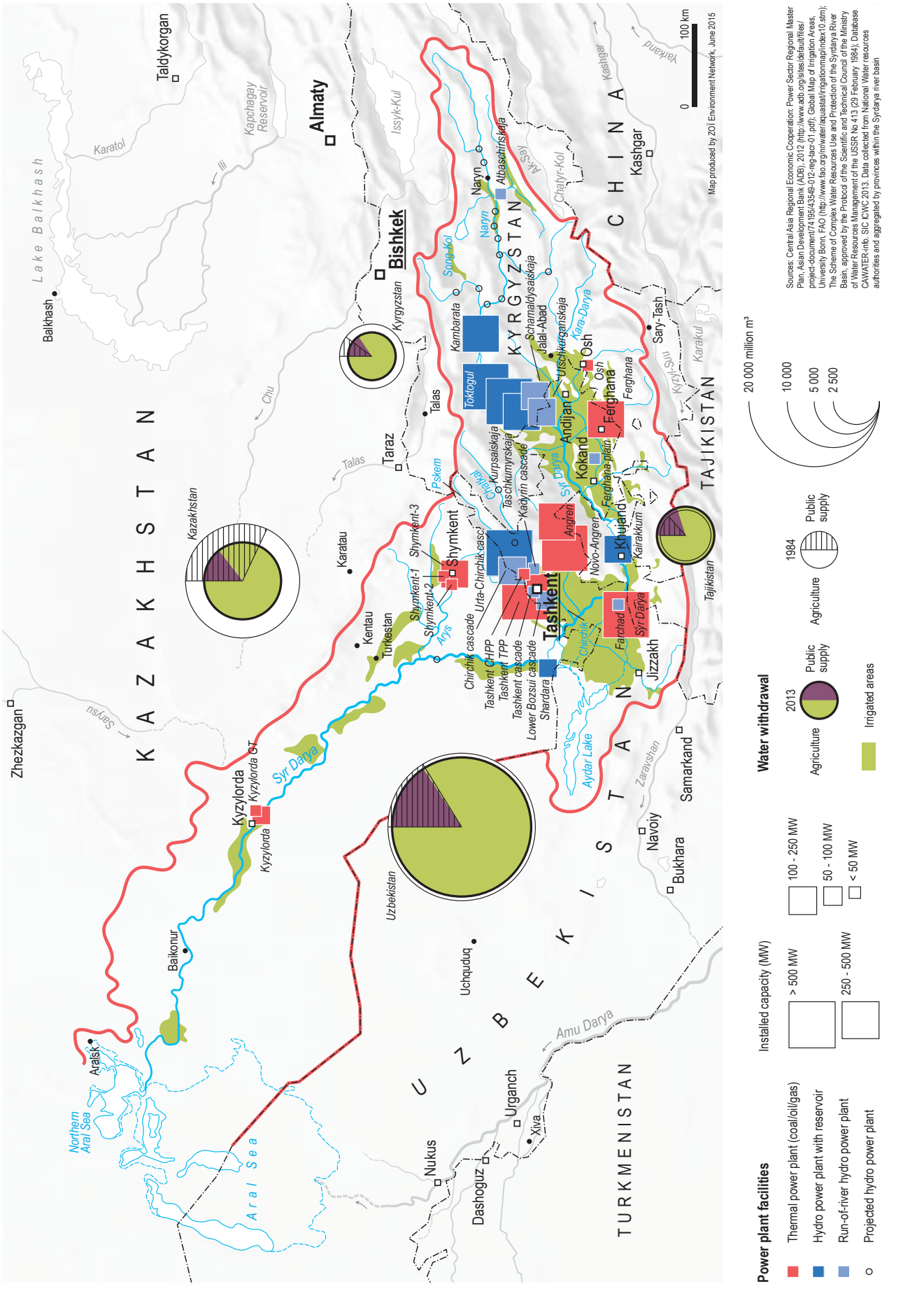

TABLE 17
The resource base in the Syr Darya River Basin and the riparian countries' dependency of it[a]

	Kazakhstan	Kyrgyzstan	Tajikistan	Uzbekistan
Country areas in the basin (as per cent of total country areas)[b]	12.7	55.3	11.0	13.5
Country areas in the basin	345,000	110,570	15,680	60,400
of total country area (hectares)	272,490,000	19,995,000	14,255,000	44,740,000
Population living in the basin (as per cent of total national population)[c]	20.0	56.6	21.2	51.4
Population living in the basin	3,406,000	3,237,000	1,739,000	15,537,000
of total national population (inhabitants)	17,037,500	5,719,500	8,207,800	30,241,100
Surface water resources in the basin (as per cent of total resources at country level)[d]	13.3	24.1	6.7	36.5
Total (actual) Surface Water Resources (RSWR) (km^3/year): within the Syr Darya Basin of the national total	13.3% of 99.63	5.1% of 21.15	1.3% of 18.91	15.4% of 42.07
Irrigated land in the basin (as per cent of total irrigated land at country level)[e]	59.3	37.3	39.3	54.4
Irrigated land in the basin	750,000	381,000	265,000	2,012,000
of total irrigated land at country level (hectares)	1,265,000	1,021,000	674,400	3,700,000
Hydropower produced in the basin area (as per cent of total national hydropower production)[f]	3.3	98.6	3.1	87.6
Hydropower produced in the basin area	418	12,663	560	5,754
of total national hydropower production (GWh)	12,525	12,847	18,144	6,566
Thermal power produced in the basin area (as a share of total national thermal production)[g]	9.03	0.00	0.00	87.1
Thermal power produced in the basin area	6,455 of 71,466	0 of 751	0 of 863	40,836 of 46,864
of total national thermal production (GWh)				

[a] The calculations of shares have been carried out using more precise values of the parameters. Due to the rounding of figures shown, minor deviations may occur.

[b] Karen Frenken, ed. Irrigation in Central Asia in Figures. AQUASTAT Survey 2012. In *FAO Water Reports 39* (Rome, FAO, 2012).

[c] World Bank (2013). *World Development Indicators*. Available from: http://wdi.worldbank.org/tables; Scientific Information Centre of the Interstate Coordination Water Commission (2013). CAWATER Info database. Available from: www.cawater-info.net

[d] Karen Frenken, ed. (2012).

[e] Calculated as: [Irrigated land] / [Area equipped with irrigation actually irrigated (country)]. *Sources:* Area equipped with irrigation actually irrigated (country). Karen Frenken (ed.) (2012); and Irrigated land – Oblast (Kazakhstan) and national level statistics offices of the riparian countries (2012), quoted by SIC-ICWC.

[f] ADB (2012). Central Asia Regional Economic Cooperation: Power Sector Regional Master Plan.

[g] ADB (2012). Central Asia Regional Economic Cooperation: Power Sector Regional Master Plan.

THE GOVERNANCE CONTEXT

Regional and basin level governance

Figure 31 provides an overview of institutions relevant to managing the resources in the Syr Darya Basin at the various levels, discussed in this assessment.

FIGURE 31
Overview of institutions relevant to managing the resources in the Syr Darya Basin

Regional level	Commonwealth of Independent States			
	Eurasian Economic Community			
Subregional level	International Fund for saving the Aral Sea			
	Interstate Coordination Water Commission (incl. 'Syrdarya' basin organization)			
	Interstate Commission for Sustainable Development			
	Central Asian Power Council			
	Central Asian Power System, Coordination dispatching Centre 'Energy'			
	KAZAKHSTAN	**KYRGYZSTAN**	**TAJIKISTAN**	**UZBEKISTAN**
	Presidents and Cabinets of Ministers			
Central Government	Ministry of Foreign Affairs	Ministry of Foreign Affairs	Ministry of Foreign Affairs	Ministry of Foreign Affairs
	Ministry of Agriculture	Ministry of Energy and Industry	Ministry of Energy and Water Resources	Ministry of Agriculture and Water Resources
	Ministry of Energy	Ministry of Agriculture and Melioration	Ministry of Agriculture	Ministry of Emergency Measures
	Ministry of National Economy	Ministry of Emergency Situations	Ministry of Economy and Trade	Ministry of Healthcare
	Ministry of Healthcare and Social Development	Ministry of Healthcare	Ministry of Healthcare and Social Protection	Ministry of Economy (responsible for fuels and hydropower)
	Ministry of Investment and Development	Ministry of Education and Science	Ministry of Industry and New Technologies	
	Ministry of Education and Science		Ministry of Education and Science	
	Ministry of Internal Affairs			
Committees and agencies	Water Committee of the Ministry of Agriculture	State Agency of the Environmental Protection and Forestry	Committee on Emergency Measures and Civil Defence	State Committee of Geology and Mineral Resources
	Committee of Geology and Subsoil of Ministry of Investment and Development	State Agency of Geology and Mineral Resources	Committee of Environmental Protection	State Committee of Nature Protection
	Committee on Protection of Consumers' Rights of the Ministry of National Economy	State Agency for Construction and Communal Utilities Development	State Committee on Investments and State Property management	Centre of Hydrometeorology
	Committee of Forestry and Hunting Ministry of Agriculture	Department of Water Economy and Melioration Ministry of Agriculture and Melioration	Agency for Land Reclamation and Irrigation	State Inspectorate for Supervision of the Energy Sector
	Committee for Construction, Housing and Communal Services and Land Resource Management of the Ministry of National Economy	Department of Sanitary and Epidemiological Surveillance at Ministry of Healthcare	Water and Energy Coordination Council under the Government of the Republic of Tajikistan	Agency for Communal and Utility Service

Committees and agencies	Committee of environmental regulation, control and state inspection in oil and gas sector of the Ministry of Energy		General Directorate of Geology	State Inspection on Supervision of Geological Examination of Subsoil, Safety Works in Industry, Mining and Communal Sector
	Committee for Industrial Development and Industrial Safety of the Ministry for Investments and Development		State Committee of Land Planning and Geodesy	State Inspection on control and supervision of the technical condition and safety operation of large and particularly important water facilities under the Cabinet of Ministers
	Committee for Emergency Measures Ministry of Internal Affairs		State Committee on Land Management and Geodesy	
			Agency for Forestry	
		State Agency on Hydrometeorology at Ministry of Emergency Situations	State Authority on Hydrometeorology	Centre of Hydrometeorological Service at Cabinet of Ministers
Intersectoral state bodies		National Water Council		
State enterprises	Kazakh Water Industry		State Unitary Enterprise Khojagii Manziliu Kommunali (KMK)	
	'Kazhydromet' State National Enterprise under the Ministry of Energy			
Energy producers	Samruk-Energy Joint Stock Company	'Electropower Stations' Joint Stock Company	'Barki Tojik'	State Joint Stock Company Uzbekenergo
	Local branches		"Pamir Energy"	
Energy transmission	'Kazakhstan Company for Management of the Electricity Grids' 'KEGOC' Joint Stock Company	National energy grid of Kyrgyzstan 'NESK' Joint Stock Company	Hukumati Viloyati (Oblast Administrations)	Local branches
			Local branches	
Energy distribution	Local branches	Joint Stock Company 'Severelectro', Vostokelectro Oshelectro and Jalalabadelectro		
Energy tariffs	Ministry of National Economy	State agency for energy and fuel complex regulation		
	Parliament			
Basin level	Water Basin Inspections	Basin Water Economy Administrations	(Water Basin Council)	Basin Irrigation System Authorities
	Basin Councils		River Basin Organization	
Local administration	Maslikhat and Akimat	Kenesh and Mayor	Madjlis and Head of local Hukumats (City, region and district Administrations)	Kengash and Hokimiat
Local level	Water user associations (WUAs)	WUAs	WUAs	WUAs

Governance of water resources

In Soviet times, the basin was managed as an integrated economic unit with agricultural production given higher priority over hydropower generation. The 'Syrdarya' basin organization was created in 1986–1987 (together with the Amudarya basin organization) to manage all water facilities on the main canals on the stem stream, and to develop (together with riparian republics) annual (seasonal) flow regulation plans. Compensation schemes managed by the Soviet Federal Government ensured that conflict over water resources among the riparian republics was avoided.[180] Following the independence of the former republics, each country began to review and revise its own economic priorities and a number of new basin institutions were established, including the Inter State Commission for Water Coordination (ICWC), the Interstate Council for the Aral Sea (ICAS), and the International Fund for Saving the Aral Sea (IFAS). In 1999, through signing the so-called Ashgabat Declaration, the countries, including Turkmenistan in addition to the Syr Darya countries, agreed to the following distribution of responsibilities among the basin organizations.

(a) The IFAS Board is the highest political level body for decision-making.

(b) The Executive Committee of IFAS (EC-IFAS) implements the decisions taken by the IFAS Board through the national branches of IFAS, including through donor financed projects.

(c) ICWC is responsible for the management of transboundary water resources, the distribution of water resources, and the monitoring of water sources and water use, as well as a preliminary evaluation of proposals for improvement or change in the organizational, technical, financial and environmental approaches and solutions related to water resources at the State level.

(d) The basin organizations, the Scientific-Information Center of the ICWC, and the ICWC Secretariat are the executive bodies of ICWC.

There are concerns that this governance system is not working well (in terms of clarity of roles, division of labour responsibilities and coordination) and that – as a consequence – regional water resources are not managed effectively.[181] Ideally the regional level institutions should help to balance the countries' divergent interests and coordinate plans that may not be fully compatible at all times. Concerned about suboptimal efficiency in the cooperation within the IFAS framework, the Heads of States – at their meeting in April 2009 – expressed their intention to improve the organizational structure and legal framework of IFAS, noting especially the need to develop a mutually acceptable mechanism for the integrated management of water resources and environmental protection in the Aral Sea Basin.[182] It is a shortcoming of intersectoral coordination that the energy authorities are not involved in the organizations of interstate water cooperation of the Syr Darya countries.

The mandate of the Syrdarya basin organization includes: (i) preparing and coordinating with ICWC the water use limits for all users in the Syr Darya River Basin; (ii) developing plans for the main water intake structures and modes of operation of cascades of reservoirs; (iii) measuring water flows at the border stations (jointly with hydro-meteorological centres); and (iv) providing a water supply to users in compliance with the limits established by ICWC. It does, however, not include water quality monitoring except for salinity. Owing to a lack of direct access to governments, the Syrdarya basin organization is not in a position to effectively carry out its mandate and it cannot serve as a platform for cross-sectoral coordination (except for solving operational problems with the Coordinating Dispatch Centre). In practice the Syrdarya basin organization only covers the part of the basin that is within the territory of Uzbekistan.

At present there is no formal bilateral cooperation between basin countries specifically on the management of the Syr Darya although some Foreign Offices may discuss bilaterally water issues ad hoc, among other matters when necessary.[183] Draft agreements for the regulation of bilateral relations on small rivers in the Syr Darya River Basin (such as the Isfara and Khodjabakirgan rivers between Kyrgyzstan and Tajikistan) are currently under consideration.

Governance of energy resources

The Central Asian States cooperate on energy within two frameworks: the CAPS and the Commonwealth of Independent States (CIS).

Established in 1970 to optimize the production and use of energy, the CAPS is a common power grid linking Uzbekistan, southern Kazakhstan, Kyrgyzstan, Turkmenistan and Tajikistan.[184] The Coordinating Council of the Central Asia United Power System (CCCA UPS) at least used to bring together national transmission system operators (KEGOC from Kazakhstan, NESK from Kyrgyzstan, Barki Tojik from Tajikistan, Kuvvat from Turkmenistan and Uzenergo from Uzbekistan) to manage the CAPS. Its CDC "Energy" for Central Asia performs the redistribution of the electrical load in the system during excessive loads or faults in the network, but it is not engaged in the planning of production and consumption of electric power. CDC does not provide for intergovernmental coordination or adoption of strategic policy decisions, but it can provide recommendations to governments.

[180] UNECE and the Economic and Social Commission for Asia and the Pacific. *Strengthening cooperation for rational and efficient use of water and energy resources in Central Asia*, United Nations Special Programme for the Economies of Central Asia (SPECA) (New York, United Nations, 2004).

[181] Sergei Vinogradov and Vance P.E. Langford (2001). Managing Transboundary Water Resources in the Aral Sea Basin. in search of a solution. *International Journal for Global Environmental Issues*, vol. 1, nos. 3/4, pp. 345–362; UNECE, Strengthening the Institutional and Legal Frameworks of the International Fund for Saving the Aral Sea: Review and Proposals. Discussion paper dated 31 January 2010. Available from: www.unece.org/fileadmin/DAM/env/water/cadialogue/docs/Draft_Paper_united_FINAL_ENG.pdf

[182] See the Discussion Paper (2010) in the previous footnote.

[183] The Commission of the Republic of Kazakhstan and the Kyrgyz Republic on the Use of Water Management Facilities of Intergovernmental Status on the rivers Chu and Talas was established in 2006 for the implementation of the Agreement of 2000 on the Use of Water Management Facilities of Intergovernmental Status on the Rivers Chu and Talas. However, the Chu and Talas basins are not a part of the Syr Darya Basin.

[184] World Bank, *Load Dispatch and System Operation Study for Central Asian Power System* (Washington D.C., World Bank, 2010).

According to the Agreement on Coordination of Intergovernmental Relations in Electric-Power Sector of the CIS, the CIS Electric Power Council was established in 1992 for general coordination to form the Common Power Market. It provides a platform for intergovernmental coordination and/or the adoption of strategic policy decisions, but at the CIS level.

National level governance

Cross-sectoral governance

The development and coordinated implementation of a national policy on water resources, agriculture, energy and environmental resources in the Syr Darya Basin countries requires a large degree of coordination between the relevant national authorities. Applying procedures for the consideration of environmental and social impacts of development plans would benefit from strengthening in all the basin countries. Some mechanisms involving intersectoral coordination have been set up by the countries, such as national strategies on sustainable development or adaptation plans on climate change. In Kyrgyzstan for example, the Coordination Committee on Climate Change coordinates activities, like the development of programmes for adaptation to climate change, by relevant ministries and agencies. The Water-Energy Council of the government of Tajikistan coordinates between various ministries and State agencies on issues related to the use of water resources, while the interministerial National Water Council in Kyrgyzstan, formally established in 2005, convened for the first time in 2013.[185]

Water governance

After the break-up of the Soviet Union, the Central Asian republics adopted new national water codes (1993–1994), and since the 2000s Kazakhstan, Kyrgyzstan and Tajikistan have also updated their water legislation with Uzbekistan looking into reform. Currently, water management is the responsibility of a specific sectoral ministry, either agriculture (Kazakhstan, Kyrgyzstan and Uzbekistan) or energy (Tajikistan). The ministries responsible for water management are also representing the countries in cooperation frameworks on transboundary water resources. Water quality management receives less attention from the authorities than water quantity issues and there is no operational framework for water quality cooperation in the Central Asia region or basins. The agencies for geology are generally responsible for groundwater resources.

A number of institutional reforms have been undertaken but sometimes left unfinished, for example, ten years after the 2005 institutional reform having been decided on in Kyrgyzstan the State Water Administration has yet to be established. Furthermore, policy development, regulatory and operational functions are not always clearly separated, for example, in Kyrgyzstan, the Department of Water Economy and Melioration of the Ministry of Agriculture and Melioration fulfils both regulatory and operational functions. Tajikistan has recently started the process of separating policymaking, regulation and operational functions.

Basin management

Since 2003, basin management has been gradually introduced in the Syr Darya riparian countries by legislative reforms that require the creation of basin-based organizations able to develop river basin plans.[186] At present, basin inspections exist in Kazakhstan, where the river basin councils have an advisory role, and in Kyrgyzstan the first basin councils have been created. But despite the legal recognition (with the exception of Uzbekistan) of the need to create basin councils, their practical work suffers from a number of shortcomings. Only in Kazakhstan does the state budget contribute to financing the meetings of the basin councils. Many relevant competencies in the countries remain with traditional state administration bodies. Despite already introducing some provisions for basin management, Tajikistan's transition towards implementing IWRM principles is in its early stages.

Land/agriculture

A crucial transformation State policy on the agricultural land management since the early 1990s has affected mainly tenure rights and involving a shift from large collective farms to smallholders. Private ownership of land has been introduced in Kazakhstan and Kyrgyzstan;[187] in Tajikistan land use rights may be the subject of transfer but land remains under State ownership; and in Uzbekistan land is under State ownership and not transferable. In addition to private intermediaries, cooperatives of different types – production, service and consumer cooperatives – sometimes offer support to smallholder farmers by, for example, facilitating access to markets, providing machinery and negotiating favourable credits.[188]

Land management committees maintain land register information (where applicable), but there is commonly no established link to land use planners.

Energy

In addition to being responsible for the energy sector, the energy ministries also oversee other matters: industry (Kyrgyzstan), environmental protection (Kazakhstan) and water resources (Kazakhstan, only from an environmental perspective, and Tajikistan). In Uzbekistan, the Ministry of Economy is responsible for fuels and hydropower. The policies in the fossil fuel producing countries (Kazakhstan and Uzbekistan) are more oriented towards the optimization of supply and the modernization of power plants, while those in the countries whose main source is hydropower focus on the expansion of hydropower generation capacity.

Environment

Environmental legislation is still being developed in the Syr Darya countries. The level of ratification of international instruments like the UNECE environmental conventions remains low, with Kazakhstan standing out as an exception. Economic development is prioritized over the protection of the environment despite the efforts of the responsible state agencies. Environmental strategies, programmes and plans are frequently in place, but their implementation is difficult because of financial constraints, among others. Limited availability of up-to-date and accurate environmental information is a constraint to development as well as the implementation of environmental policies.

Decentralization

The process of dismantling collective farms gave rise to peasant farms and – finally – to the reform of water management and relevant management structures (decentralization and privatization), including the establishment of water user associations (WUAs). However, WUAs, which assumed control over irrigation networks, are a weak link in operational water management. They need strengthening to make them more efficient and less dependent on state water management structures. One important challenge is that their financing needs to be improved. Local authorities are mainly responsible for land use/urban planning; In Kazakhstan there is also general territorial planning.

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185 OECD and UNECE, *Integrated Water Resources Management in Eastern Europe, the Caucasus and Central Asia* (2014).

186 The introduction of governing institutions at the basin level was initiated in Kazakhstan from 2005 to 2008 (River Basin Councils), in Uzbekistan from 2003 (Basin Irrigation System Authorities), in Kyrgyzstan in 2008 (Talas Basin Council), and in Tajikistan the establishment of such structures is in progress.

187 UNECE, *Country profiles on the housing sector: Kyrgyzstan* (New York and Geneva, United Nations, 2010).

188 Zvi Lerman. Structure and Performance of Agriculture in Central Asia. Discussion paper. Hebrew University of Jerusalem, Department of Agricultural Economics and Management, 2013. Available from: http://ageconsearch.umn.edu//handle/164530

DRIVERS OF PRESSURES ON BASIN RESOURCES

Agriculture

Agriculture is the largest consumptive water user in the basin, constituting 84–86 per cent of withdrawals from the basin in all countries.[189] Large irrigation schemes along the river has led to a severe reduction of water flows reaching the Aral Sea with significant consequences for the environment as well as the livelihoods and health of local populations, such as an increased frequency of sand and dust storms and a decline of fisheries.[190] Groundwater is not widely used for irrigated agriculture but is traditionally used for livestock, and its importance for crop production is growing with water scarcity and droughts.[191] Irrigation is characterized by inefficient water use due to system losses caused by degraded, aged infrastructure that still makes up a significant share, as well as suboptimal management. The use of water efficient technologies remains for the time being quite limited (localized or sprinkler irrigation is often below one per cent), but plans and water efficiency targets set by Kazakhstan, and modernization programmes in Uzbekistan, are gradually improving the situation.[192] Poor irrigation and drainage practices and poorly functioning infrastructure aggravate soil salinization (a serious problem across the basin) causing waterlogging, the contamination and mineralization of groundwater, and water quality degradation.[193, 194] Irrigated agriculture creates a high energy demand for pumping water during the growing season, notably in Uzbekistan and Tajikistan. Run-off from agricultural land is the main source of water pollution in the Syr Darya River.

Energy production and distribution

The basin area is strategic for the development of oil and gas pipeline networks as well as power transmission lines. In addition to the present hydropower plant installations the basin has the potential for further electricity generation, and there are plans to export electricity produced in the basin to China and South Asia through high voltage transmission lines, which have yet to be established. Upstream hydropower facilities have shifted to winter production to meet peak electricity demand in Kyrgyzstan, which has reduced water availability in the growing season for agriculture downstream,[195] altered ecosystems in many areas along the river, and led to flooding along the river in the winter time. Water is required for cooling in thermal energy production, mainly located in Uzbekistan and to a lesser degree in Kazakhstan. Efficiency of electricity transmission could be improved in all the countries to reduce the pressure on the basin's resources and related economic losses. For example in Kyrgyzstan, grid losses in recent years have reached 16–18 per cent on distribution lines and 5–6 per cent on transmission lines.[196]

Mining and industry

In all riparian countries, pollution from mining and industry affects the water quality of the river and its tributaries. Sources of pollution include uranium extraction in Kazakhstan, tailing ponds in Kyrgyzstan, manufacturing in Tajikistan, and metallurgical and chemical industries in Uzbekistan.

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189 Oblast (Kazakhstan) and national level statistics offices of the riparian countries, quoted by ICWC-SIC.

190 UNEP, *The future of the Aral Sea lies in transboundary co–operation* (2014). Available from: http://na.unep.net/geas/getUNEPPageWithArticleIDScript.php?article_id=108; Oleg E. Semenov (2012). Dust storms and sandstorms and aerosol long-distance transport. In Breckle, S-W., Wucherer, W., Dimeyeva, L.A., Ogar, N.P. (Eds.) Aralkum – a Man-Made Desert: The Desiccated Floor of the Aral Sea (Central Asia), *Ecological Studies*, vol. 218. pp. 73–82; Andy Thorpe and Raymon van Anrooy, *Inland fisheries livelihoods in Central Asia, policy interventions and opportunities* (Rome, FAO, 2009).

191 Karen Frenken, ed. Irrigation in Central Asia in Figures. AQUASTAT Survey 2012. In FAO Water Reports 39. (Rome, FAO, 2012).

192 A relevant example is the IWRM-Fergana project, which involved national teams from Kyrgyzstan, Tajikistan and Uzbekistan funded by the Swiss Development Cooperation and implemented with technical assistance from the International Water Management Institute and ICWC-SIC. The project managed to reduce water losses (its primary objective) involving multiple levels of governance and employing agreed procedures and methods for equitable and stable water allocation under the control of water users. *Source:* GWP, Integrated water resources management in Central Asia: The challenges of managing large transboundary rivers. Technical Focus Paper. (Global Water Partnership, 2014).

193 UNESCO, *Groundwater Cooperation in Central Asia*. National presentations from Kazakhstan, Kyrgyzstan and Tajikistan (Paris, UNESCO, 2014). Available from: http://groundwatercop.iwlearn.net/gefgwportfolio/syrdarya

194 Karen Frenken, ed. (2012). See footnote 26.

195 World Bank, *Water and Energy Nexus in Central Asia, Improving Regional Cooperation in the Syr Darya Basin*. (Washington D.C., World Bank, 2004)

196 TECHECONOMMODEL. Study on the application of energy efficiency and renewable energy advanced technologies in Central Asian Countries. A report for the United Nations Office in Geneva. (Kraainem, Belgium, 2013); Ministry of Energy and Industry of Kyrgyzstan.

Household consumption and waste

Some settlements depend heavily on groundwater sources for drinking purposes, for example, in Kyrgyzstan 99 per cent of centrally distributed drinking water in cities comes from groundwater resources, while in rural areas about 70 per cent of the drinking water is abstracted from surface resources. Untreated wastewater due to infrastructure shortcomings puts major pressure on the quality of water resources. For example, in Tajikistan, 80 per cent of wastewater treatment facilities are worn down and need renovation. Households rely increasingly on electricity for heating, especially in urban areas in Kyrgyzstan (35 per cent)[197] and Tajikistan (85 per cent).[198] This type of demand peaks in winter and is mainly met with hydropower production.[199] Use of wood and biomass, as a result of unavailable or unaffordable alternative fuels in rural settlements, is causing localized deforestation, loss of forest related ecosystems and increased erosion[200] on top of high levels of indoor air pollution.[201]

Insufficient regional economic integration

The Syr Darya Basin, and the region of Central Asia more generally, are becoming increasingly important for energy production and export as oil and gas pipelines and electricity grids are being expanded to supply large external markets such as China and South Asia. Riparian countries have prioritized self-sufficiency over economic cooperation, which has led to the adoption of uncoordinated solutions that increase pressure on the shared water resources. Prospects of improved trade, for energy and food in particular, could however mitigate the consequences with the energy trade potentially playing a major role in the development of the energy sector of all the countries. Technically, the necessary infrastructure is in place but at present the political situation does not allow for the related benefits to be realized. The development of a regional market for agricultural products also has a high potential to positively influence economic growth of the countries in the region, as well as their choice of crops. Kazakhstan and Uzbekistan are already leading wheat exporters[202] and there is a potential to expand the fruit and vegetables market.[203]

Climate change

Important inter-annual variations in the demand-supply water balance have been observed, likely influenced by changing climatic conditions. Freshwater availability in Central Asia, particularly in the large river basins, is projected to decrease due to climate change in the long term, even though the predictions vary and in the short term an increase may also be experienced.[204] With the predicted continuation of temperature increase and related evapotranspiration, the melting of glaciers will slowly cause a decrease in water stocked at the source. Long-term changes in the snow cover have been observed the Central Asian Mountains, including an ongoing shift towards earlier snowmelt, which slowly changes the regional hydrology.[205]

[197] World Bank, *Keeping Warm: Urban Heating Options for the Kyrgyz Republic* (Washington D.C., World Bank, 2015). Available from: www.worldbank.org/en/news/feature/2015/02/25/urban-heating-options-for-the-kyrgyz-republic

[198] Daryl Fields and others. *Tajikistan's Winter Energy Crisis: Electricity Supply and Demand Alternatives* (Washington D.C., World Bank, 2012). Available from: http://siteresources.worldbank.org/ECAEXT/Resources/TAJ_winter_energy_27112012_Eng.pdf

[199] It is worth noting that the total primary energy consumption per capita in Kyrgyzstan and Tajikistan is low compared to Kazakhstan and Uzbekistan, influenced by various factors relevant to energy intensity of a nation's economy: KZ – 150, KG – 44, TJ – 26 and UZ 78 (million BTU per person).

[200] UNECE, Second Environmental Performance Review of Uzbekistan. In *Environmental Report Series No.29* (New York and Geneva, United Nations, 2010) Available from: www.unece.org/fileadmin/DAM/env/epr/epr_studies/uzbekistan%20II%20e.pdf

[201] World Bank, *Keeping Warm: Urban Heating Options for the Kyrgyz Republic* (Washington D.C., World Bank, 2015).

[202] FAO, *Food Outlook*. Biannual report on Global Food Market (Rome, FAO, 2014). Available from: www.fao.org/3/a-i4136e.pdf

[203] UNECE, Regulatory and procedural barriers to trade in Kazakhstan. (New York and Geneva, United Nations, 2014) Available from: http://www.unece.org/fileadmin/DAM/trade/Publications/ECE-TRADE_407E-Kazakhstan.pdf

[204] IPCC, *Fifth Assessment Report* (AR5), (Geneva, IPCC, 2014) Available from: www.ipcc.ch/

[205] Andreas Dietz and others (2014). Identifying Changing Snow Cover Characteristics in Central Asia between 1986 and 2014 from Remote Sensing Data, *Remote Sensing*, vol. 6(12), pp. 12752-12775.

FIGURE 32
Key indicators describing the resources and socioeconomics of the Syr Darya countries

SYR DARYA BASIN

River length **3,019 km**
River basin area **410,000 km²**

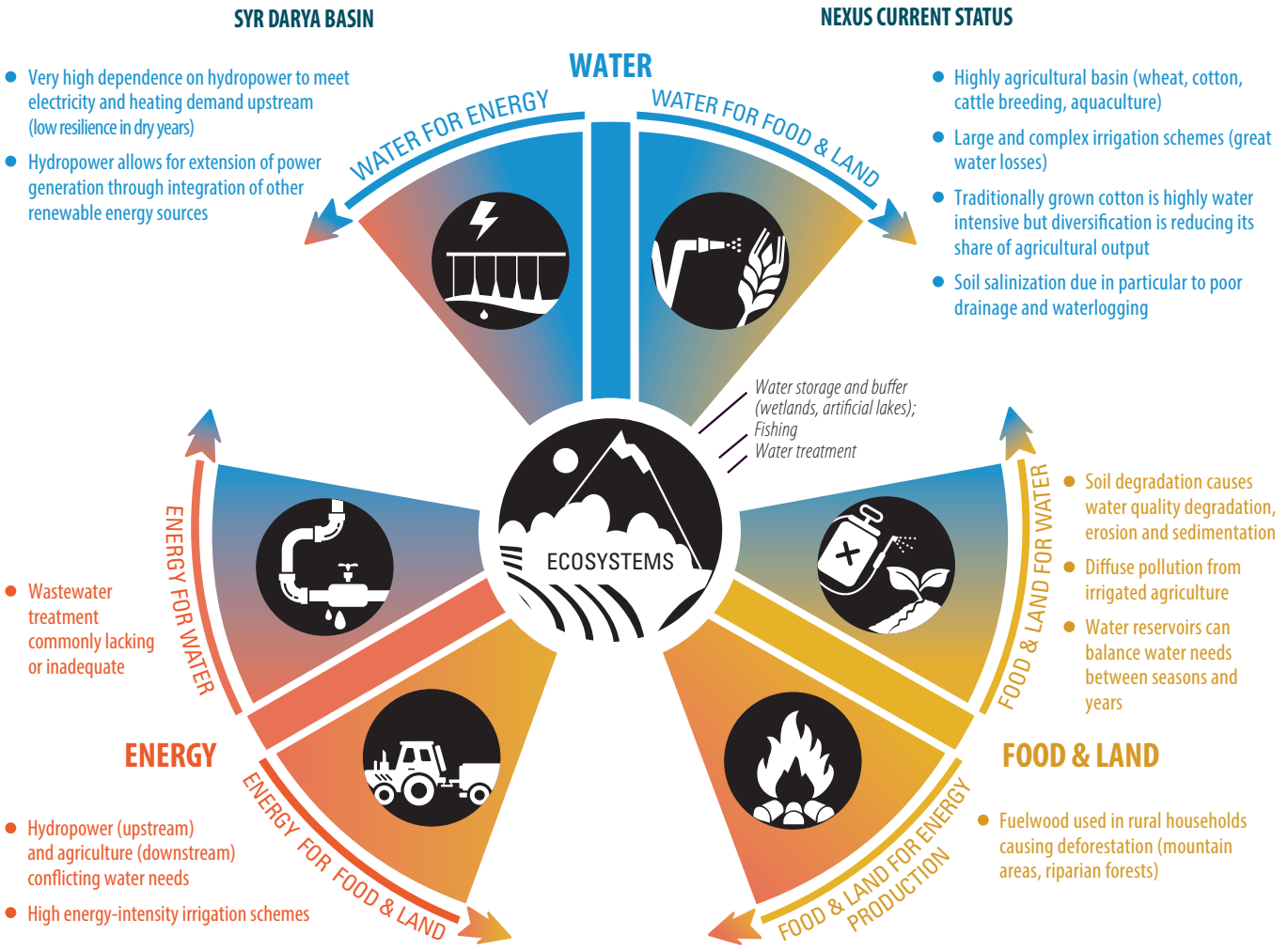
KYRGYZSTAN	TAJIKISTAN	UZBEKISTAN	KAZAKHSTAN
INTERNAL RENEWABLE WATER RESOURCES			
National: 48,930 million m³/year	21,910	48,870	108,400
Syr Darya Basin: 28,500	2,000	12,000	5,400
Surface, groundwater and return flow, 1999			
WATER WITHDRAWAL			
8,000 million m³ (2006)	11,500 (2006)	56,000 (2005)	21,100 (2010)
Agriculture 93%	Agriculture 91%	Agriculture 90%	Agriculture 66%
Industry 4%	Industry 3%	Industry 3%	Industry 30%
Municipal 3%	Municipal 6%	Municipal 7%	Municipal 4%
Syr Darya Basin: 2,700 (2013)	3,900	22,700	6,900
INSTALLED ELECTRICITY GENERATING CAPACITY			
3.8 million kW	5.1 million kW	12.6 million kW	17.8 million kW
Hydropower 3.0 (79%)	Hydropower 4.7 (92%)	Hydropower 1.7 (14%)	Hydropower 2.3 (13%)
Fossil fuels 0.8 (21%)	Fossil fuels 0.4 (8%)	Fossil fuels 10.8 (86%)	Fossil fuels 15.6 (87%)
AGRICULTURAL LAND			
105,900 km² (2012)	48,750 km²	266,900 km²	2,079,800 km²
of which 21% is potentially irrigable	of which 32% is potentially irrigable	of which 18% is potentially irrigable	of which 2% is potentially irrigable
NATIONAL GROSS DOMESTIC PRODUCT			
7,200 million (current USD, 2013)	8,500 million	56,800 million	231,900 million
POPULATION			
5.7 million	8.2 million	30.3 million	17 million
Syr Darya Basin 3.2 million (57%)	1.7 million (21%)	15.5 million (51%)	3.4 million (20%)

Sources: Scientific-Information Center of the Interstate Commission for Water Coordination of Central Asia (SIC ICWC), 2013 ; FAO ; US EIA ; World Bank, 2015.

ANALYSING NEXUS LINKAGES

Energy, water and land resources are closely linked in the Syr Darya Basin. Figure 33 provides an overview of the current status of nexus linkages. In the Syr Darya Basin water-energy and water-land links are particularly important.

FIGURE 33
Nexus linkages in the Syr Darya Basin



Energy and Water

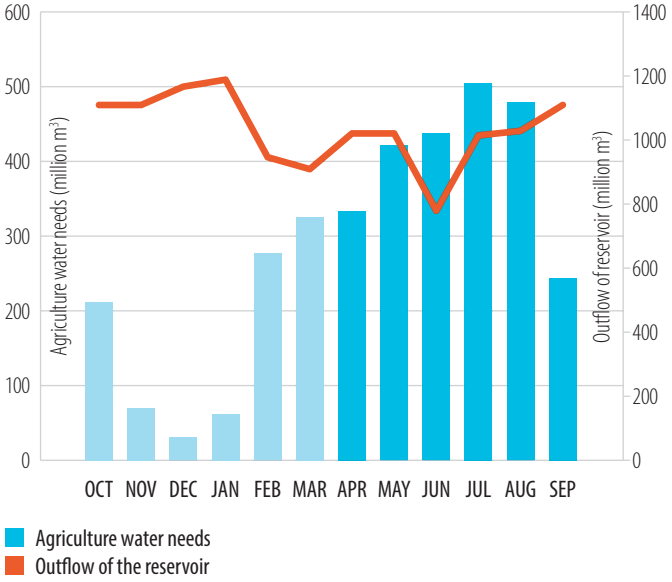
Kyrgyzstan and Uzbekistan are dependent on the basin water for energy production. Kyrgyzstan is heavily reliant on hydropower, while the majority of Uzbekistan's thermal power plants use Syr Darya Basin water for cooling. Kyrgyzstan, where hydropower is the main source of energy, operates upstream reservoirs predominantly based on a winter power production regime adapted to the peak demand resulting from heating needs.[206] Water discharges from upstream dams are therefore higher in winter months, which limit access to water for irrigation during the growing season (figure 34). Energy and irrigation needs can be covered during wet years with mild winters, but during dry years and cold winters both sectors may suffer. In dry years, demand for irrigation is high, while the water availability depends on the availability of snow and glacial melt, in addition to flow regulation. A dry vegetation season with low melt water availability followed by a cold winter is a recipe for a critical situation for both the irrigation and energy sectors.[207] Water shortages in the summer have already been reported to affect thermal power plants in the Syr Darya Basin.[208]

The 1998 Agreement on the Use of Water and Energy Resources in the Syr Darya River Basin[209] provided a framework for energy exchanges and the regulation of water discharges until the early 2000s, but was gradually phased out. While international development partners since then have suggested similar approaches the countries have not been able to find a solution.

Energy requirements for pumping water in the large-scale irrigation and drainage systems are significant.

FIGURE 34
Trade-off between hydropower and agricultural water needs

Discharges of the Toktogul dam and Fergana valley needs by month in 2011.
The year 2011 was average in terms of water availability.



Source: Central Asia Water Info database (ICWC-SIC).

Water and Land

As a consequence of the extensive irrigation development in the 1950s and 1960s the level of the Aral Sea has declined severely and is presently divided into several smaller water bodies the level of which depends on the annual inflow. However, as an exception the Northern part of the Aral Sea fed by Syr Darya has stabilized after the construction of the Kok-Aral Dam.

Unsustainable practices in irrigation and drainage led to soil salinization and seriously declining soil fertility.[210] The upstream part is affected by erosion and much of the irrigated land downstream is salinized and/or waterlogged. The latter effects have largely been caused by the suboptimal irrigation practices and degraded infrastructure. Land degradation and salinization over decades has led to a high periodic water use so as to wash away the salts, and the problem remains important despite some efforts to recover salinized soils.[211]

While agriculture contributes to water pollution through agricultural inputs (fertilizers and pesticides in particular), the level of fertilizer use (nitrogen, phosphorus and potassium) in the Syr Darya Basin has decreased significantly since Soviet times due to their high cost. Limited wastewater treatment also contributes to pollution of the river, as does the return of salinized drainage water to the river flow.

Reducing the volumes of applied irrigation water, optimizing reclamation as well as improving management and use of drainage waters can reduce soil salinization and changes to water quality due to run-off from agricultural land. This could help increase yields, save water and limit soil degradation and erosion. Some gradual rehabilitation and modernization of existing irrigation systems, including the introduction of drip irrigation, has been carried out, notably in Kazakhstan and Uzbekistan. According to SIC-ICWC's information, the application of irrigation water has been reduced in Uzbekistan from some 18,000 m^3/ha in 1990 to 10,500 m^3/ha in 2008.

The investment costs, low water quality and insufficient capacity of farmers are some factors complicating the upscaling of water efficient technologies such as drip irrigation.

[206] As previously stated, the main hydropower production and potential of Tajikistan is outside the Syr Darya Basin, and the main hydropower production upstream, discussed here, takes place in Kyrgyzstan. The shift in operation regime has been gradual from the flow regulation system's initial optimization for agricultural production (cotton at the time).

[207] World Bank, *Water and Energy Nexus in Central Asia, Improving Regional Cooperation in the Syr Darya Basin.* (Washington D.C., World Bank, 2004)

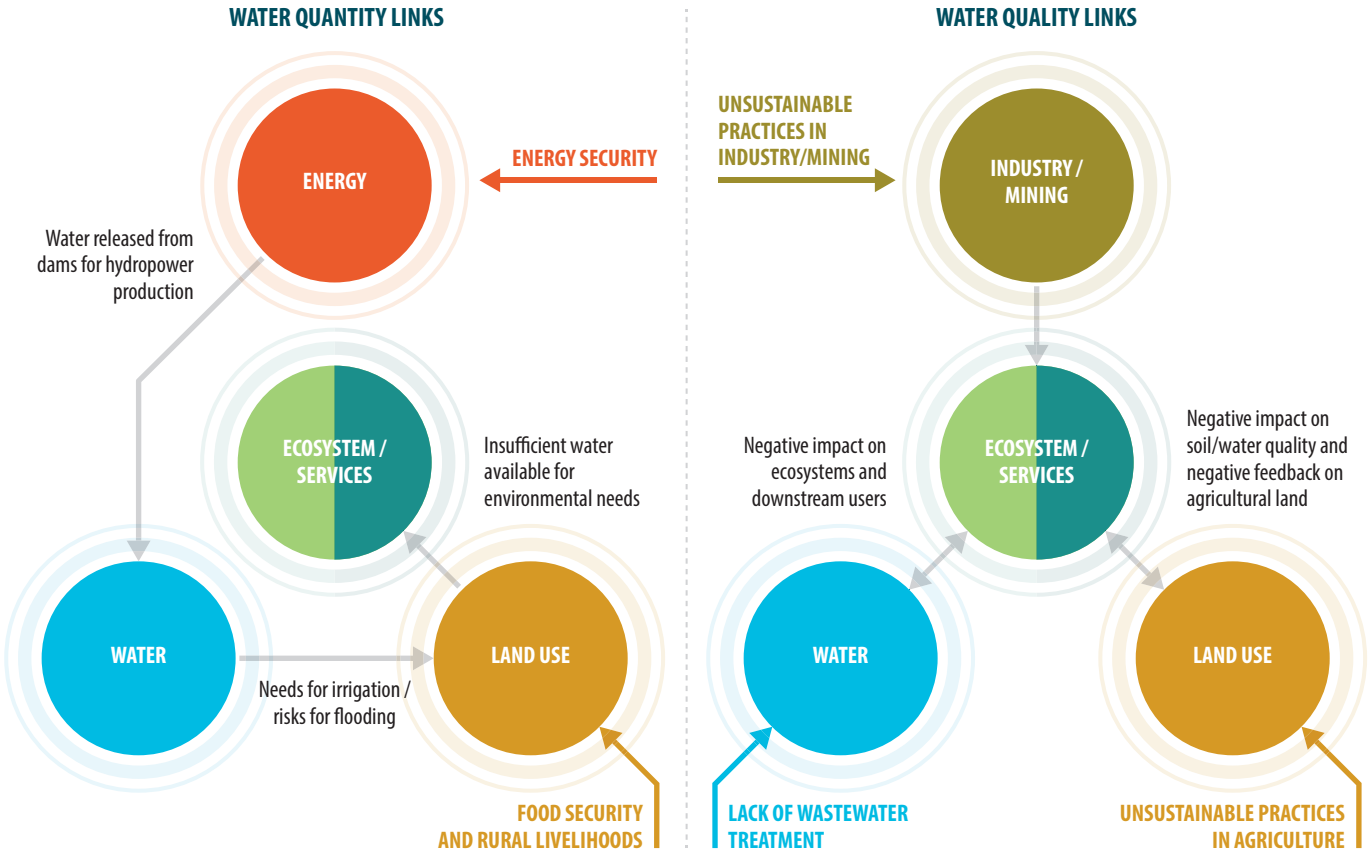
[208] Artur Kochnakyan and others, *Uzbekistan: Energy/Power Sector Issues Note* (Washington D.C., World Bank, 2013).

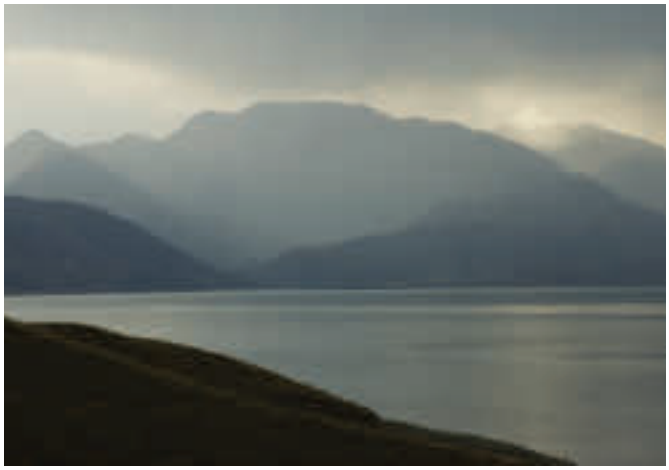
[209] This agreement was concluded in 1998 between Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan.

[210] Among such unsustainable agricultural practices in the Syr Darya Basin are, for example, monocropping of cotton, inappropriate use of fertilizers and pesticides, inadequate soil management, overgrazing of pastoral lands.

[211] For example, Uzbekistan reported having reduced the extent of saline soils by 60,000 ha in five years in response to a government decree adopted in 2007.

FIGURE 35
Nexus interlinkages identified in the Syr Darya Basin





Future trends

The links between land, water and energy resources will evolve in the future in ways that are not easy to predict. Regarding energy-water links, the Kambarata-1 dam in Kyrgyzstan would have a much smaller water capacity than the Toktogul (4,650 million m^3),[212] but higher generation capacity (around 1,860 MW). This dam may further diminish access to irrigation water downstream,[213] but it may also allow for the Toktogul to return to an irrigation regime in the interest of the downstream countries. Kyrgyzstan is planning for the project work and drawing up plans related to the completion of technical documentation and fundraising to be completed in 2015, for the hydroelectric unit of Kambarata-2 to be commissioned in 2018, and for the construction of Kambarata-1 to be completed in 2022.[214] In recent years, there has been a tendency to construct dams downstream to serve the supply of irrigation water as well as counter-regulation – the Koksarai dam in Kazakhstan being one such example.

Overall annual freshwater withdrawal in Central Asia is presently decreasing but the demand for water can be expected to expand with population growth. A dryer and warmer climate may further increase irrigation needs. These upward pressures could be counter-balanced by the gradual replacement of degraded infrastructure with low water use efficiency. Present plans indicate that the area under irrigation may be reduced in Uzbekistan, remain stable in Kazakhstan and increase in Kyrgyzstan and Tajikistan (Workshop 2014). It is an open question whether water savings from improved efficiency will be used for recovery of ecosystems or for the expansion of economic activities. Groundwater may become increasingly important for agricultural needs,[215] resulting in higher demand for energy for pumping. At the same time, all countries are oriented towards crop diversification and in particular towards a shift in production from cotton to less water intensive crops (input from the countries, FAO and Workshop, 2014).

A short scenario-thinking exercise at the workshop, facilitated by FAO, revealed some key uncertainties that will affect the future such as the development of regional cooperation, geopolitics, population movement (migration of rural population and workers in agriculture) and climate change.

[212] UNECE, *Dam Safety in Central Asia: Capacity Building and regional cooperation* (New York and Geneva, United Nations, 2007).

[213] Uzbekistan has expressed concerns about a risk of such reduction of flow happening and affecting agricultural water use in the country.

[214] Information on the implementation of projects in the field of energy, Ministry of Energy and Industry of Kyrgyzstan. Available from: www.energo.gov.kg; and from: www.24.kg/ekonomika/16806/

[215] Karen Frenken, ed. Irrigation in Central Asia in Figures. AQUASTAT Survey 2012. In *FAO Water Reports 39*. (Rome, FAO, 2012).

FIGURE 36
Future trends in the Syr Darya Basin and the riparian countries

BASIN TRENDS

TEMPERATURE	↗↗
PRECIPITATION	↗↘
ECOSYSTEM SERVICES	→
WATER RESOURCE AVAILABILITY	↘
POPULATION	↗
ECONOMY (medium term)	↗

↗ RISE ↗↗ SIGNIFICANT RISE
↘ DROP → STABLE
BY 2030

NATIONAL TRENDS	KYRGYZSTAN	TAJIKISTAN	UZBEKISTAN	KAZAKHSTAN
WATER FOR FOOD & LAND Irrigation needs	↗	↗	↘	↘
WATER FOR ENERGY Electricity generation needs, cooling	↗↗	↗	→	↘
ENERGY FOR WATER Treat, move and store water	↗	↗↗	↗↗	↗
ENERGY FOR FOOD & LAND Grow, store, process and move food	↗↗	↗↗	↗	↗
FOOD & LAND FOR ENERGY Food-energy competition for water, biofuel production	↗	↘	→	→
IMPACT OF FOOD & LAND ON WATER RESOURCE Water pollution, agricultural use	↗	↗	↗	↗

EXPLORING SOLUTIONS

The nexus assessment of the Syr Darya includes the preliminary identification of possible solutions to improve the management of the basin's land, water, energy and environmental resources. These potential solutions have been classified under five headings: institutions, information, instruments, infrastructure, and international cooperation and coordination. Some of the riparian countries have already taken action in a number of areas.

Prioritizing national solutions over solutions based on cooperation has established a vicious cycle. Solutions based on self-sufficiency lead to negative effects on co-riparians, as well as an additional loss of trust and decreasing opportunities for the advancement of cooperation.

Cooperation involving all the countries as well as sectors has in contrast a great potential in terms of optimizing the use of available resources. Coordinated monitoring and information exchange on water quality and hazards would allow for better planning of activities all along the river. Restoring cooperation is therefore a challenging but necessary objective to pursue, as a minimum goal in the longer term. However, restoring cooperation will take time and national issues in the meantime remain a priority. Reducing poverty and improving rural livelihoods are, for example, among the highest policy objectives in all countries.

In this sense, it would be easier in practice to first apply solutions that focus on national development, which have also (possibly unintended) co-benefits at basin level (indicated by (a)) followed by solutions that focus on broader sustainable development and national policy coherence, in order to build more favourable conditions for transboundary cooperation (b), and finally solutions that accelerate national development by furthering cooperation (c).

Institutions

- **Developing institutional capacities** to support the optimal allocation of basin resources and the development of integrated approaches to resource management (such as integrated management of land, water and energy), as well as resource management at the local level (such as by local authorities and water user associations) (a).
- **Adapting the national legal frameworks** to support the implementation of new technical solutions (such as recycling water in industry, including the energy industry but also – with adequate controls – in agriculture) (a).
- Developing mechanisms to identify and incorporate the wider nexus impacts in sector-based policy development leading to more integrated planning processes with high-level political backing (b).
- **Undertaking institutional reforms in the nexus sectors** to separate policy-making, regulation and implementation roles; clarify roles and responsibilities to avoid gaps and overlaps; and support the creation of decentralized institutions (such as sub-basin councils and water user associations) (b). Improving intersectoral coordination at the basin level by increasing representation of and consultation with the relevant ministries, notably energy ministries, in water management institutions and processes (c).

Information and research

- **Developing and implementing a results oriented research agenda,** including for example, socioeconomic analyses of the adoption of new irrigation technologies (drip, sprinkler, sub-surface) and technical analyses of the most effective energy technology upgrades (for cooling, for more efficient combustion at thermo-electrical plants etc.) (a).
- **Improving monitoring, data management and forecasting,** in particular to ensure the resilience of energy generation and agricultural production activities (a).
- **Expanding agricultural extension programmes** to support switching and diversifying crop-shifting as well as sustainable land management practices, including the adoption of water saving technologies (a).

Instruments

- **Implementing policy mixes to support energy efficiency** through energy efficiency standards, public awareness and pricing reforms (a). Kyrgyzstan increased electricity tariffs for 2014–2015 and there are indications that the electricity consumption decreased by about 20 per cent.[216]
- **Reforming water and energy pricing** both to support a more rational use of water and energy resources and to generate financial resources to pay for infrastructure upkeep and modernization (a). For example, Kazakhstan has implemented volumetric water tariffs with differentiated tariffs across oblasts according to water scarcity levels.
- Stepping up enforcement of environmental regulations (a).
- **Adopting environmental flow standards** so as to ensure that the water flow into the North Aral Sea does not fall below an established minimum (currently estimated to be 5 km^3 per year) (b).[217]

Infrastructure

- **Investing in the modernization of built infrastructure to ensure the preservation and protection of the basin's resources,** which includes energy transmission lines to reduce system losses and to expand trading possibilities, irrigation canals and equipment to increase water efficiency, and wastewater treatment plants to reduce water pollution (a).
- **Investing in diversification of energy sources, particularly in upstream countries** – since use of renewable energy sources such as wind (in Tajikistan) and small hydro (in Kyrgyzstan) would reduce peak demand for large hydropower (a).
- **Investing in expanding electricity networks and re-establishing grid interconnection** to facilitate the development of a more integrated regional energy market as well as energy exports to non-riparian countries. Developing connections to sell electricity outside the region could make the summer discharge operation regime more interesting, as well as upstream in the basin (c).

International coordination and cooperation

- Clarifying roles and responsibilities of basin institutions and developing their capacities (a).
- **Improving basin-wide monitoring, data verification and exchange, and knowledge-sharing,** including joint monitoring (e.g. water flows and quality), joint forecasting (e.g. energy demand), as well as the identification of good practices at local and national level (b).
- Developing a regional energy market and exploring opportunities for energy-water exchanges (c).

[216] In five months of 2015, electricity consumption was reported to have decreased by 1.2 billion kWh. In August 2015, a further electricity price increase in Kyrgyzstan was announced from 0.70 som to 0.77 som per kWh for those using less than 700 kWh. Above 700 kWh, the tariff is higher. *Source: People began to consume less electricity - the State Agency for Energy*, (Babylon, 5 August 2015). Available from: http://babylon.kg/ekonomika/. The reduction is notable even with the winter that was not very cold.

[217] The Scheme of Use and Protection of the Syr Darya River Basin (1982) specified that the environmental flow to the Aral Sea should be 3 km^3 in a low water year and 5 km^3 in a high water year including the demands of fisheries and the delta of the Syr Darya. A recent estimate by Nariman Kipshakbayev and others (2010) is 2.732 km^3 for the requirements of the Syr Darya delta and 3 km^3 for discharge to the Aral Sea, adding up to a total of 5.7 km^3. Nariman Kipshakbayev and others, *Ecosystem Restoration in the Syr Darya Delta and Northern Part of the Aral Sea* (Almaty, Evero, 2010). Available from: http://www.eecca-water.net/file/north_aral_ru.pdf (in Russian).

IDENTIFYING THE BENEFITS OF ADOPTING A NEXUS APPROACH

By adopting a nexus approach to the management of the Syr Darya basin's water, energy and land resources as well as ecosystem services, riparian countries could exploit many potential benefits, including increasing efficiency in resource use and overall sustainability. Adoption of the nexus approach would, for example improve resource security, building on the complementarity of the resource bases, as well as develop resource intensive economic activities where the conditions are favourable. The results of a rapid scoping of those benefits are summarized in table 18. As discussed in section 'The benefits of adopting a nexus approach' in chapter 4, even at the transboundary level, these benefits are ultimately enjoyed by individual countries. Table 18 follows the analytical framework of the UNECE policy guidance note on identifying, assessing and communicating the benefits of transboundary water cooperation.[218]

TABLE 18
The benefits of transboundary cooperation in the management of resources of the Syr Darya Basin

	On economic activities	Beyond economic activities
From improved management of basin resources	**Economic benefits** • Protection and increased viability of economic activities relying on water resources (including fisheries and tourism) • Increased security of energy and water supply • Increased revenues from energy and food exports • More diversified, resilient and dynamic agricultural sector • Reduced economic costs of water related hazards (in particular droughts and related power blackouts) • Reduction of infrastructure development costs (thanks to avoidance of duplication and sub-optimal location)	**Social and environmental benefits** • Reduction of poverty (e.g. through agricultural sector development) • Protection of resource based livelihoods • Health benefits from improved water quality • Increased access to and improved sustainability of energy and water services • Improved status and stability of riverine ecosystems • Reduced greenhouse gas emissions
From increased trust among Syr Darya countries	**Regional economic cooperation benefits** • Development of regional markets for goods (in particular agricultural products), services (in particular electricity) and labour • Increased cross-border investments • Multiple uses of infrastructure better provided for	**Geo-political benefits** • Improved likelihood of attracting financial resources from development cooperation partners • Compliance with international agreements

CONCLUSIONS AND RECOMMENDATIONS

The Syr Darya's basin resources play a key role in the economy and development of each riparian country

The basin provides fertile agricultural land and water resources that support hydropower generation and irrigated agriculture. The basin also hosts transport routes for some of the world's largest oil, coal and natural gas reserves originating from the Caspian Sea area.

The basin's resources are under large and increasing pressures

The drying up of the Aral Sea and the related degradation of the environment graphically exposes the dramatic extent of some of those pressures. In addition to water use for irrigation, the basin also experiences pressures from energy development, industrial development, household consumption and climate change. In turn, this affects the socioeconomic development of the basin population, energy and food security, and the sustainability and resilience of economic activities including agriculture. In the future, environmental and social challenges will become increasingly urgent as resource demands increase with higher living standards.

Most links between countries and sectors in the basin take place through water resources

The Syr Darya's water resources are central to hydropower generation in upstream countries as well as agricultural production in upstream and downstream countries. There is a clear trade-off as demand for energy in upstream countries peaks during winter, while irrigated agriculture requires water releases in summer time. These demands and dependencies could be reduced: for energy,

[218] UNECE, *Policy Guidance Note on the Benefits of Transboundary Water Cooperation: Identification, Assessment and Communication* (New York and Geneva, United Nations, 2015).

through an increased diversification of energy sources, energy trade and improved energy efficiency, and for water through furthering the ongoing transformation of agriculture involving improved water use efficiency, crop switching and land reform, among others. Water quality issues, driven by untreated wastewater discharges and inadequate agricultural practices, are also relevant given their human health and environmental impacts.

Reduced cooperation has left riparian countries more exposed to external shocks

In Soviet times, the basin resources were to a significant extent managed in an integrated way to address development as well as production priorities with compensation mechanisms facilitating the acceptance of centralized planning decisions. Since 1991, cooperation between countries has decreased despite the establishment of agreements and a number of basin governance institutions at the Aral Sea level. Opportunities to seize cooperative solutions have been missed, in particular on energy exchanges and water discharges, leading the countries to act independently and without coordination to ensure economic growth and resource security. This has not only caused transboundary tensions but also increased the exposure of each country to external shocks.

Transboundary cooperation in the management of basin resources can generate large economic benefits

But a lack of trust between riparians is a serious bottleneck. Cooperative solutions are available and could generate massive economic benefits by reducing input costs, increasing the value of agricultural production, promoting exports of energy carriers, enhancing the sustainability of economic activities, reducing the costs of droughts and power cuts, and promoting cross border investments and the development of regional markets for goods, services and labour. Improved cooperation in managing the basin resources can also generate a number of social and environmental benefits, including poverty reduction, employment generation, health benefits, improved status of riverine ecosystems and geopolitical benefits.

Realizing the potential benefits of improved management of the basin resources demands an ambitious programme of action

Such a programme would encompass: (i) energy diversification in upstream countries to reduce dependency on hydropower in winter time and crop diversification; (ii) modernization of energy and water infrastructure to minimize system losses; (iii) policy packages to increase energy and water efficiency (including pricing reforms, public awareness campaigns, and the introduction of energy efficiency standards); (v) agricultural extension programmes to support crop-shifting and the adoption of sustainable resource management practices; and (iv) the development of regional energy and agricultural markets. Planning and implementation of such measures would also require institutional reforms and capacity development to facilitate basin-wide integrated resource planning both at national and basin level. The draft Third Aral Sea Basin Programme (ASBP-3), a regional action plan for 2011–2015 to alleviate the environmental and socioeconomic consequences of the Aral Sea disaster and to facilitate progress towards IWRM and sustainable development in the Aral Sea basin,[219] envisages addressing a number of topics relevant to the nexus. Improving the efficiency of the responsible institutions operating in the area of water and related resources in Central Asia (the Interstate Commission on Sustainable Development [ICSD], ICWC and IFAS) requires harmonization, better coordination and the improvement of their relations. The involvement of the energy sector in the basin-wide cooperation would improve the opportunities for addressing nexus issues, as reflected in this report.

The riparian countries are already taking various initiatives that go in the direction of the identified solutions[220] both technical and in the field of legislation and policy

Furthermore, at the level of national strategic documents (for example the Presidential Degree in 2014 on Kazakhstan's Transition to Green Economy, the National Sustainable Development Strategy of the Kyrgyz Republic for 2013–2017), the importance of efficiency and sustainability in managing (nexus) resources (water, arable land, energy and/or environmental services) is recognized, in some cases with explicit set targets. However, unless concerted action is taken, there is a risk that efforts do not achieve the desired level of impact. Improved coordination, between the riparian countries but also between sectors at the national level, is necessary to that end. Improved transboundary relations, as well as consistency in national policies (making a business case for energy efficiency and renewable energy production, providing incentives for rational water use etc.) would improve investor confidence, which is important for mobilizing resources, in particular for major projects.

Moving forward will require progressive trust-building to gain high-level political backing

The Syr Darya Basin is an example of a river basin where there are evident trade-offs across sectors, resulting in inefficient use of resources, environmental degradation and tension between riparian countries. Transboundary cooperation would benefit from an improved understanding of the different sectoral needs and how these needs can be reconciled. A number of efforts to enhance resource management, based on integrated approaches and the promotion of multi-sectoral cooperation, have already been proposed in the basin. But presently the riparian countries find themselves in a vicious cycle in which solutions based on self-sufficiency lead to negative effects on co-riparians, an additional loss of trust and decreasing opportunities for the advancement of cooperation. Uncoordinated national policies risk pushing countries further away from each other and undermining opportunities to optimize resource use and maximize benefits. Transboundary relations and confidence in cooperation could and should be developed step by step, paying attention to actions that, while benefitting national economic development, also decrease pressures on shared natural resources, increase efficiency of sectors and strengthen economic ties between the countries.

This scoping level nexus assessment only provides an overview of the importance of the basin's resources, the intersectoral linkages, potential solutions and untapped benefits

Further analytical, stakeholder engagement and planning work is needed to identify precise governance reforms, policy measures and investment opportunities to address the challenges and seize the opportunities.

[219] The Board of the IFAS reviewed the draft ASBP-3 in December 2010 in Almaty, Kazakhstan, and submitted it for approval to the IFAS member States (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan). IFAS, *Serving the People of Central Asia: Aral Sea Basin Program 3* (ASBP-3). Executive Committee of the International Fund for Saving the Aral Sea (International Fund for Saving the Aral Sea, 2010).

[220] For example, Uzbekistan informed having already installed water efficient drip irrigation systems covering more than 15,500 ha of cultivated land, and plan to extend the drip irrigated area up to 25,000 ha by 2017.

CHAPTER 8
Conclusions and recommendations

This chapter presents and summarizes general conclusions drawn from the nexus assessments carried out under the Water Convention in 2013–2015. It also outlines a number of recommendations for future assessments under the Convention and is also intended for any country, organization or other actor interested in embarking on a nexus assessment in a transboundary basin, including the application of the methodology developed under the Convention.

Approach, opportunities and challenges

To ensure ownerships and impact of the exercise, the nexus assessment under the Water Convention was scoped and designed with the following principles in mind, i.e. the process should:

- **be participatory;**
- **mobilize knowledge;**
- **be based on sound scientific analysis;**
- **build capacity;**
- **be a collective effort and reflect the diverse stakeholders views; and**
- **uncover benefits and opportunities.**

It is important to tailor the scope and focus of nexus assessments to the level of existing cooperation, and to consider how the assessment results can be used by existing or future policy and cooperation processes. In the Alazani/Ganykh Basin there is some transboundary cooperation on a technical level but it has not been formalized. If an agreement is concluded within the envisaged multisectoral scope, the bilateral commission (to be established) could address some of the issues identified in the nexus assessment. In the Sava Basin, where transboundary cooperation is well developed and the International Sava River Basin Commission offers an established platform, the nexus assessment focuses on exploring how to better involve the energy and agriculture sectors in basin cooperation, including with the support of quantitative modelling techniques. Finally in the Syr Darya Basin the existing institutional capacity for transboundary cooperation is not being used owing to the lack of trust and understanding between the riparian countries. Therefore the nexus assessment focuses on national policies and technical measures that could help to address the nexus challenges while reducing pressure on the shared resources and hence create more favourable conditions for advancing transboundary cooperation.

An active participation and commitment from the countries in the process is necessary to shape the practical application of the nexus assessment approach into a valuable exercise that responds to relevant policy questions and supports decisions at different levels. It is possible that on some occasions the complexity of the nexus issues or concerns about going beyond the confines of their mandates held the participants back from providing input more actively.

Already carrying out a nexus assessment provides countries with a number of benefits, above all, it offers an opportunity to take a fresh look at, or re-energize, the process of transboundary water cooperation. The benefits from a nexus assessment exercise for the countries involved include: an improved knowledge base (including an analysis and quantification of selected aspects) to support decision-making and policy development; joint identification of opportunities for concrete benefits through, for example, intersectoral synergies; intersectoral, transboundary dialogue; exchange of good practices across countries and between basins on addressing intersectoral issues; capacity-building; an increased awareness, and stimulation for further action.

The Water Convention's nexus approach provides a good basis for the identification of cooperation opportunities. A main objective of the nexus assessment is to show that transboundary cooperation is needed to tackle nexus challenges, and the approach provides for doing so in a manner that is non-prescriptive, inclusive and indicative, highlighting a broad range of potential opportunities. This focus on concrete opportunities makes the Water Convention's

nexus approach a compelling tool to develop much needed local-to-national, cross-sectoral and transboundary cooperation.

To advance dialogue, even in sensitive contexts, the nexus assessment methodology tackles the transboundary dimension somewhat indirectly. Direct dialogue happens between sectoral groups rather than country groups to potentially reduce tensions even if sectoral objectives may not be fully compatible. This helps to advance dialogue in sensitive contexts. In the Water Convention's nexus approach, transboundary cooperation is discussed explicitly at the end of the assessment process, i.e. when examining solutions and benefits.

Undertaking several assessments in parallel opens up the possibility for mutual learning and exchange of experiences. Carrying out several assessments under the Water Convention's framework made it possible to share experience both between the basins and more generally in the framework of the Task Force on the Water-Food-Energy-Ecosystems Nexus, including in relation to the identified solutions. For example, the Guiding Principles on Sustainable Hydropower in the Danube Basin (including the Sava Basin), effective afforestation by switching fuel in households in the Alazani/Ganykh Basin, and crop diversification to reduce irrigation water requirements in the Syr Darya Basin are all "nexus relevant" experiences that can inform similar efforts in basins grappling with similar challenges. In terms of governance, the multisector framework in the Sava Basin provides for intersectoral dialogues at the transboundary level, and in the Syr Darya Basin – despite the current challenges – the existence of an institutional framework for water allocation at the transboundary level is also noteworthy, to mention a couple of examples.

Important considerations when carrying out a nexus assessment

A nexus assessment as described here should be viewed as a scoping exercise and a first step on a longer process to develop and broaden water cooperation. The nexus assessments only provide an overview of the importance of each of the basin's resources, their inter-sectoral linkages, potential solutions and untapped benefits. Subsequently, a process focused on specific issues, with objectives set accordingly and jointly with the concerned authorities and key stakeholders, needs to be launched to allow further progress. From the perspective of policy support, the methodology only sets the basis and provides a number of recommendations for countries and joint bodies to consider. For example, it does not include cost and benefit analysis of different policy actions nor is it a substitute for risk analysis. These more focused and in-depth types of analyses can be relevant next steps, following up on the application of the nexus methodology. Therefore further analytical and policy work is needed to specify and detail possible governance reforms, policy measures and investment opportunities to address the challenges and seize the opportunities identified in the nexus assessment.

The findings from each nexus assessment are both context specific and process specific. They depend on the specific governance context, the current pressures on resources, and the interlinkages experienced in each basin. They also depend on the quality of the nexus assessment in each basin, as determined by the availability of information, the resources available for the assessment, and the level of participation of the key authorities and other stakeholders.

Defining the scope and process of the nexus assessment appropriate to the needs and the status of cooperation is of primary importance. Nexus assessments are flexible tools that can respond to very different needs; but such flexibility needs to be carefully managed. The nexus assessment could be oriented towards: (i) restoring cooperation; (ii) reviewing the scope of cooperation or to identify new opportunities for cooperation; (iii) quantifying interlinkages for setting priorities or for determining whether measures are required; or (iv) assessing the appropriateness of a certain policy. An advanced level of dialogue in the basin usually allows a nexus assessment to have a specific scope, focusing on further analyzing already established issues and advancing concrete proposals for addressing them. In other cases, where the most problematic issues might be known but cooperation might not function for various reasons, the nexus approach can serve to broaden (or restart) the dialogue beyond strictly water allocation discussions, which are typically more controversial.

Attention should be paid to the institutional platform under which the nexus assessment will be carried out, as well as the partners involved and how it will be financed. The fact that the nexus assessments were part of the Water Convention's programme of work and carried out under the auspices of the Convention was an important factor in ensuring official engagement. At the same time, this implied an emphasis on water resources when involving the countries. Partners with different sectoral mandates are therefore invaluable. FAO facilitated the outreach to the agriculture and land management sector, and the UNECE Sustainable Energy Division provided pertinent insights into the energy sector. Adequate resources and budgets are required for organizing workshops, coordinating the work of different analysts, supporting experts, collecting data and ensuring good communication with country officials.

Expectations need to be managed. Due to the broad scope of the nexus assessment, the expectations of assessment outcomes are highly diverse and therefore easily susceptible to disappointment. The resources and time needed to develop a truly interactive process and to actively coordinate with the different countries and experts should not be underestimated. In the three assessments carried out under the Convention, the limitation of resources has constrained the ambitions of the exercise.

It is important to be prepared for unpopular findings and solutions. The results of a nexus assessment can challenge the interests of one or more of the sectors or countries involved. It is therefore important to have a robust institutional platform on which to discuss them.

Highly participative basin-wide workshops are a key element of the nexus assessment. They provide an invaluable opportunity to gather up-to-date information and insights about the issues, exchange views across sectors, which seldom happens under current management practices, and generate ideas about solutions. The participants became very engaged in the discussions, working rather intuitively with complex interlinkages using graphs. At the same time, remote consultations with stakeholders are key to complement the workshop, allowing to involve a greater number of actors.

Even though intersectoral-transboundary dialogue is valuable per se, adequate data is necessary for a meaningful analysis. Frequently up-to-date data at the basin level or at the level of local administrative units is unavailable and the national level situation is not always a good proxy for the respective country's share of the basin. Having adequate, harmonized and up-to-date data becomes even more important if the countries decide to follow up on some of the conclusions and study the implications and benefits of some of the response actions in more detail.

The complexity of the nexus calls for improving – and at times simplifying – communication about the nexus issues and also making it more visual. **Among the challenges it is important to have clear and accessible communication on the interlinkages and intersectoral effects,** not only to bring attention to the findings, but also to facilitate input by the participants during the assessment process.

The potential solutions identified during the basin assessments demonstrate the utility of the Water Convention's nexus approach. These solutions have been jointly identified by national stakeholders and international partners involved in the development of the three basin assessments. Even though many solutions are not new, the participation of multiple sectors allows for potentially new approaches and wider awareness-raising. Moreover, the nexus perspective elicits a broader scope of impact analysis and response identification compared to conventional integrated water resources management. Examples of solutions identified that illustrate nexus responses include: changing household energy use in one country to improve flood management in another; increasing the use of renewable energy to increase water releases and promote irrigated agriculture; and undertaking multipurpose water management to ensure energy security and the meeting of low carbon growth goals.

Continued intersectoral dialogue at the transboundary level on possible actions to take in response to the nexus assessment's findings is an important next step of the assessment exercise. Follow-up opportunities include: getting the stakeholders to discuss the findings and possible responses to the recommendations of the assessment; exploring who (which sector, organization, etc.) is in a position to address the potential solutions identified; and identifying the concrete actions that could be undertaken by a particular actor – all of which are important in enhancing the impact of the assessment. In the Water Convention's programme of work for 2013–2015 (thanks to the support of the European Union's Water Initiative and Germany), it was possible to hold further consultations, however, more efforts in this direction are needed. Opportunities to include such follow-up of existing initiatives and processes would be very beneficial.

The methodology has proved to be suited to very different basins with very different conditions. It provides a flexible framework: general enough for wider application globally yet adapting to the specific conditions and the various issues at stake. The methodology can also be expected to be well suited for application to aquifers (groundwater). Its application can be tailored to the means on hand, the available data, and the amount of funding and local support. Partnerships can add to the wealth of and level of detail in the findings.

While the methodology developed is demonstrably applicable and valuable, **the experience with the basin assessments suggested a number of possible improvements:**

- A technical nexus assessment and an assessment of the governance aspects need to be better synchronized and progress hand-in-hand.
- The governance analysis of the energy and land management/agriculture sectors need to be strengthened, including through the revision of the tools and work aids used (e.g. questionnaires).
- The mapping of organizations and key actors should be carried out as early as possible so as to best define the actors to be involved. Depending on how the identification of participants is carried out, as well as the role played by national administrations or joint bodies in this identification, this will influence the representation of sectors and interests in the process. A more comprehensive representation of all the sectors concerned would be beneficial.
- There is potential for the local contracted experts to play a more active role so as to significantly support the process, provided the management of the input is optimized. Involving a larger number of local experts would also strengthen capacities in the countries. Further efforts should therefore focus on this aspect.
- A more systematic discussion over present and future trends would add great value and clarity to the assessment. More attention should be paid to the impact that trends will have on the interlinkages, and which ideally should also be quantified
- A second workshop for discussing the findings and possibilities of addressing some of the identified issues should ideally be held at the level of the transboundary basin, although discussing them nationally, and involving all the relevant sectors, is also useful.

Addressing the nexus: implications for management

The implementation of a nexus approach requires good information to improve national level intersectoral coordination and the development of a shared knowledge base for transboundary cooperation. The nexus assessment highlights gaps in information. For instance, the potential benefits of identified options for cooperation across sectors and countries (for example savings of water or energy that are feasible to obtain) need to be further substantiated with explicit calculations. The review of tools presented in chapter 3 lists options which Governments, joint bodies and other actors could consider using in order to quantify some of the issues identified in the scoping assessment. Aspects such as data intensity, user-friendliness, resources available (including time), and accessibility of the tools, i.e. whether they are open-source, needs to be considered when making the selection.

Economic and policy instruments have a great potential to address trade-offs, including through promoting resource use efficiency and limiting pollution. However, their cross-sectoral impacts should be assessed more systematically and comprehensively before putting them in place. Economic instruments, i.e. water and energy pricing, but also different environmental fees, can provide behaviour-altering incentives and also raise funds for infrastructure maintenance and development as well as environmental protection. Strategic Environmental Assessment is an example of a policy instrument that promotes a consideration of alternatives and consultation of the different interests. Beyond individual instruments, the nexus assessments call for coherent mixes of policy instruments and investments, and in many cases they also step up enforcement of environmental regulations.

Where integrated water resources management is already being implemented, there exists a better basis for applying a nexus approach since there is current knowledge of some of the issues and the different sectoral stakeholders, making it thus easier to broaden further the knowledge base into economic sectors and the engagement of the different sectors.

In most cases, the sustainable management of basin resources will require larger investment in infrastructure, both grey and green. In general, it will not just be about investing more, but about investing better. Investing better means taking into account the broader intersectoral or environmental implications of the investments and coordinating them with related sectoral investments (this could even involve multi-purpose designs) and assessing the risks. Coordinating hydropower and other renewable energy investments is a case in point, i.e. pumped storage type hydropower facilities serve to integrate more intermittent renewable energy sources such as wind and solar power into the energy systems, which underlines the value of optimizing siting of these installations. Natural (or green) infrastructure, including floodplains and riparian areas for example, can in some cases substitute or complement built (or grey) infrastructure. Adequately assessing the suitability of the technical solution to the particular setting while evaluating the risks is also necessary. Moreover, changes in other sectors can drastically change the calculations of feasibility, pay-back times etc. For example, adopting drip irrigation systems in place of gravity irrigation systems needs to factor in possible changes in the price of energy.

Responding to challenges and seizing the opportunities requires stronger multisector transboundary planning and coordination, but an effective intersectoral coordination, even at the national level, is difficult to achieve irrespective of the level of economic development. In many of the cases assessed, the energy sector policy would have an important role in the solutions. At the same time, even though the basin cases illustrate that the links between water and energy extend far beyond hydropower, the energy sector was not easy to engage. Coordination between regional economic organizations, basin organizations and energy organizations/ power pools is key.

Enhanced transboundary cooperation on the management of the basin resources will bring significant benefits. The findings suggest that where cooperation is limited, riparian countries are more exposed to external shocks. The economic cost of non-coordination can also be significant, for example, when multiple use of an infrastructure cannot be agreed costly investments can be made in response so as to duplicate or extend infrastructure, or obstacles to trade can lead to production that is not well supported by the resource base. National level actions such as improving efficiency in water and energy use – which are in countries' own economic interest – can reduce the pressure on shared resources and progressively build trust to gain high-level political backing. Complementarities in different sectors (e.g. in the energy mix) can create a broader package of benefits that are achievable through cooperation. Multisectorality in setting up or revising cooperation is therefore an opportunity.

Applying a nexus approach does not necessarily require putting in place specific "nexus governance". In strengthening the institutional capacity, it is recommend, as a first step, to build on existing organizational structures, further developing them and broadening their scope of work. Notably, many river basin organizations, and other joint bodies, already have a multisectoral scope and consequently they can function as effective platforms for the dialogue and negotiation of developments with intersectoral and transboundary impacts, and can thus reach agreement on actions requiring the involvement of several sectors. An appropriately broad representation of sectors in the joint bodies can facilitate such a role. Political will is of key importance in ensuring intersectoral coordination and transboundary cooperation. Even if formal structures and processes facilitate interaction between sectors and increase mutual understanding, their existence does not necessarily guarantee coordination.

Ultimately, stronger and more coherent national policies are needed to "manage the nexus". Various intersectoral coordinated processes can help align policies, among them for example, national sustainable development strategies, adaptation plans on climate change, Strategic Environmental Assessment and Environmental Impact Assessment, as well as regional development strategies and integration processes (e.g. EU approximation, where applicable).

ANNEX I

Glossary of key terms used in the nexus assessment

Term	Definition
Components of the nexus	Water, energy, land use and ecosystems are often referred to as "sectors" and sometimes as "resources". This ambiguity is justified by the fact that they could be considered either way depending on the context of discussion. In a general way, they can be referred to as "components of the nexus".
Ecosystem services	The direct and indirect contributions of ecosystems to human well-being.[a] They are normally divided into "provision", "support", "regulation" and "cultural services".
Ecosystems (component of the nexus)	A dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit.
Energy (component of the nexus)	Energy resources, energy production (including electricity), transportation/transmission of energy and energy access (clean, constant and safe).
Energy productivity	The ratio between the wealth produced by a certain activity and the energy used to produce it. It can refer to the overall economy of a country or to a single sector/activity.
Food (component of the nexus)	Land resources and types of land use, with a strong focus on agriculture (crop production, fishing and livestock), but considering also urban areas, forestry, etc. Due to the scope of the assessment, the food component of the nexus is commonly referred to as agriculture or land.
Governance	The rules and mechanisms that characterize how a society functions. Specifically, the governance analysis of a nexus assessment looks at the legislative, institutional and policy framework of the basin, the countries and the region.
Integration	The act of considering different sectors (or institutions) together. In general terms, better integration means improved cooperation, communication and collaboration. Integrated modelling refers to the merging of different models (e.g. the energy model and the water model) to obtain combined results.
Interdependency	A relation of mutual dependency or influence, here referring to sectors or actors involved in the assessment.
Interlinkage (between sectors)	Relations existing between two sectors. They may be unidirectional (impact from one sector on another) or bidirectional (trade-offs, affecting each other).
Modelling	The conceptualization of a system using quantitative and spatial information to allow for the representation of resource flows and evolutions. This is usually done using appropriate tools.
Nexus	The nexus term in the context of water, food (agriculture) and energy refers to these sectors being inextricably linked so that actions in one area commonly have impacts on the others, as well as on ecosystems that provide vital services to these sectors.
Nexus issue	A problematic situation that affects more than one sector.
Nexus solution	An intervention that would benefit more than one sector, in this context including also interventions that reduce the pressure on ecosystems (or the environment at large).
Policy coherence	Policy coherence implies that the incentives and signals of different policies to target groups are non-conflicting. Policy coordination and policy integration help to increase coherence, introducing processes and means that reduce coherence problems between sectors.[b]
Reconciling (different uses)	Finding solutions to tensions or conflicts related to the multiple needs/uses of a common resource.
Resource scarcity	A resource can be scarce in absolute or relative terms. In the first case, scarcity refers to a physical lack of availability (e.g. water scarcity means aridity). In the second case, scarcity is related to the uses of such resource. A large demand of one resource simply reduces its availability for other uses.
Scenario	An expected or possible situation characterized by certain conditions. Usually, factors such as climate change or important policy actions serve to characterize such scenarios.
Sector	In general terms sectors are resource users. They can be both productive (e.g. industry) and consumptive (e.g. households).
Synergy	A synergy is an action that two or more actors take together. By coordinating, the parties normally need to invest less effort than by acting separately.
Trade-off	A balance achieved between two desirable but incompatible features; a sacrifice made in one area to obtain benefits in another.[c]
Water (component of the nexus)	Water resources and their management, water services (utilities, infrastructure including irrigation schemes) and water access (safe drinking water, sanitation)
Water productivity	The ratio between the wealth produced by a certain activity and the water used (withdrawn) to produce it. It can refer to the overall economy of a country or to a single sector or activity.
Water-food-energy-ecosystems nexus	An extension of the traditional water-food-energy nexus, the water-food-energy-ecosystems nexus gives a more prominent role to ecosystems and the services they provide. It should be noted that the present assessment's food component focuses on agriculture (sector) and land (resource) management- related aspects.

[a] Definition from The Economics of Ecosystems and Biodiversity (TEEB) website www.teebweb.org/resources/glossary-of-terms/.

[b] For a review of the terms and some relevant literature, see, e.g. Per Mickwitz and others, *Climate Policy Integration, Coherence and Governance* (Helsinki, Partnership for European Environmental Research, 2009).

[c] Definition from the Oxford English Dictionary.

ANNEX II

Indicators and sources

The table in section A below provides a list of non-spatial indicators, broken down into three groups (screening indicators; perspectives indicators; and assessment-specific indicators), along with suggested sources. Section B provides a listing of potential sources for 12 geospatial indicator groups (administrative country data; socioeconomic data; hydrological basins, rivers and irrigation maps; digital elevation; land cover; lakes and wetlands; protected areas; agricultural production area; urban areas; water risks; and forest change), as well as some additional indicator sources.

The list proposed for screening indicators is not comprehensive, but provides a good overview of the basin and its riparian countries.

For all indicators, preference is given to national statistics and indicators received directly from national authorities.

A. Non-spatial indicators

Groups of indicators	Suggested sources
I. SCREENING INDICATORS	
Basin[a]	
Physical characteristics • Length • Basin area • Country's share • Land use by type	FAO Aquastat Database[b] UNECE Second Assessment of Transboundary Rivers, Lakes and Groundwaters[c]
Withdrawals in the basin: • Total withdrawal • Agricultural share • Domestic share • Industry share • Energy share	FAO Aquastat Database[b]
Transboundary underground aquifers: • Border length, area and thickness, mean and maximum • Main groundwater uses • Groundwater management measures	UNECE Second Assessment of Transboundary Rivers, Lakes and Groundwaters[c]
Groundwater balance: • Precipitation • Total flow • Inflow • Infiltration river • Infiltration precipitation • Discharge evaporation • Discharge river	UNECE Second Assessment of Transboundary Rivers, Lakes and Groundwaters[c]
Renewable water resources in the basin:[d] • Mean annual run-off • Internal renewable surface water resources by country	FAO Aquastat Database[b]
Wastewater information: • Wastewater generated • Wastewater treated (primary, secondary, tertiary treatment)	UNECE Second Assessment of Transboundary Rivers, Lakes and Groundwaters[c]
Stress (ranking): • Baseline stress • Inter-annual variability • Seasonal variability • Flood occurrence • Drought severity	World Resource Institute Aqueduct Database[e]
Country	
Gross Domestic Product (GDP): • GDP growth • GDP growth per capita	World Bank World Development Indicators Database[f]
Population: • Population growth • Rural population • Rural population growth • Population density	

Groups of indicators	Suggested sources
Contribution of natural resources to GDP: • Total natural resources rent • Oil rents • Natural gas rents • Coal rents • Mineral rents • Forest rents Population below national poverty line	World Bank World Development Indicators Database[f]
Employment by sector (in agriculture, industry, services)	World Bank World Development Indicators Database[f]
Contribution to total GDP by sector (agriculture, industry, services)	World Bank World Development Indicators Database[f]
Water productivity: • In agriculture • In industry • In services/domestic use	To be calculated on the basis of water withdrawals and GDP (by sector)
Energy productivity: • In agriculture • In industry • In services/domestic use	To be calculated on the basis of energy consumption and GDP (by sector). This information needs to be made available from country statistics (no openly accessible database).
Water resources: • Actual renewable water resources • Internal renewable resources • External renewable resources • Quantity of flow reserved to upstream and downstream countries through formal or informal agreements or treaties • Renewable water resources per capita	FAO Aquastat Database[b]
Water use: • Annual freshwater withdrawal • Withdrawals for agriculture • Withdrawals for industry • Withdrawals for domestic use • Access to improved water source • Access to improved sanitation facilities	World Bank World Development Indicators Database[f] FAO Aquastat Database[b]
Land: • Land area • Forest area • Permanent cropland • Arable land • Arable land per person • Total wood resources • Logging harvest (official) • Logging harvest (illegal) • Agricultural irrigated land • Average annual precipitation • Land under cereal production • Fertilizer consumption • Agricultural machinery	World Bank World Development Indicators Database[f]
Energy: • Energy production total • Energy use • Energy use per capita • Use of fossil fuels • Combustible renewable and waste • Alternative and nuclear (including hydropower) • Energy use growth	World Bank World Development Indicators Database[f]
Electricity: • Electricity production: - From coal - From natural gas - From oil - From hydropower - From renewables - From nuclear • Electricity access	World Bank World Development Indicators Database[f]
Environment: • Threatened species (mammals) • Threatened species (birds) • Threatened species (fishes) • Threatened species (higher plants) • Terrestrial protected areas • Marine protected areas	World Bank World Development Indicators Database[f]
Emissions: • Carbon dioxide (CO_2) emissions per unit of GDP • CO_2 emission per capita • Total CO_2 emissions	World Bank World Development Indicators Database[f]
II. PERSPECTIVES INDICATORS	
Difference of opinions by country, by area of expertise (sector): • Overview of the basin • Water quality and quantity • Food and land use • Energy • Environment	Opinion-based questionnaire
III. ASSESSMENT-SPECIFIC INDICATORS	
Interlinkage 1 Interlinkage 2 etc. Solution 1 Solution 2 etc.	Previous studies, experts, authorities

[a] Not all indicators are available for all basins.

[b] Available from http://www.fao.org/nr/water/aquastat/main/index.stm.

[c] United Nations publication, Sales No E. 11.II.E.15. Available from http://www.unece.org/?id=26343.

[d] Information on water mass balance and on the intra-annual distribution of flow would be very useful, the latter also in particular in relation to water uses, which may be highly seasonal.

[e] Available from http://www.wri.org/our-work/project/aqueduct.

[f] Available from http://data.worldbank.org/data-catalog/world-development-indicators.

B. Geospatial indicators

All data related to geospatial indicators are collected in GIS-readable formats (raster-based maps or geographically referenced information).

1. Administrative country data

Administrative areas and boundaries. Global Administrative Areas database (GADM), Year: 2012. Available from http://gadm.org/.

2. Socioeconomic data

Open source maps and data. European Commission Joint Research Centre (JRC), "Environmental Monitoring" web page. Data also include elevation and slope data as "distance to markets" maps. Available from https://ec.europa.eu/jrc/en/research-topic/environmental-monitoring?search.

Country and population data. Socioeconomic Data and Applications Center, SEDAC. Available from http://sedac.ciesin.columbia.edu/.

3. Hydrological basins, rivers and irrigation maps

The boundaries of the hydrological basins and irrigation-related maps are extracted from FAO AQUAMAPS global spatial database on water and agriculture. Available from http://www.fao.org/nr/water/aquamaps/.

Homogeneous European catchments data set at scale 1:1 million. Year: 2006. Available from EEA at www.eea.europa.eu/data-and-maps/data/.

4. Digital elevation

The CGIAR-CSI GeoPortal provides global SRTM 90m Digital Elevation Data, Year: 2003. Available from http://srtm.csi.cgiar.org/ and www.cgiar-csi.org/.

5. Land cover

Land cover data. FAO (land degradation assessment in drylands, land use system maps) and JRC (global land cover) databases. Available from www.fao.org/ and https://ec.europa.eu/jrc/, respectively.

Land cover classes. GLC2000 data set produced by JRC, Year: 2008–2000. Available from https://ec.europa.eu/jrc/.

6. Lakes and wetlands

Spatial information about wetlands, water bodies, rivers and other water-related land forms. 1:1 to 1:3 million resolution. The global lakes and wetlands database, World Wide Fund for Nature, Year: 2004. Available from https://www.worldwildlife.org/pages/global-lakes-and-wetlands-database.

7. Protected areas

Protected Planet Database on Protected Areas, Year: 2012. Available from http://protectedplanet.net/.

8. Agricultural production area

Agriculture indicators are based on the Global Agro-Ecological Zoning model (GAEZ) from the International Institute for Applied Systems Analysis (IIASA) and FAO. Available from http://www.fao.org/nr/gaez/en/ and www.gaez.iiasa.ac.at/.

9. Urban areas

30 arc-second land area grid. Global Rural-Urban Mapping Project (GRUMP), Socioeconomic Data and Applications Center (SEDAC), Year: 2000. See http://sedac.ciesin.columbia.edu/.

Night-time light. The Earth Observation Group of the National Geophysical Datacenter. Lights and combustion sources, Year: 2000. Available from http://ngdc.noaa.gov/eog/.

10. Water risks

AQUEDUCT GLOBAL MAPS 2.0, which includes 12 global indicators related to a water risk framework (physical risk quantity, physical risk quality, regulatory and reputational risk), Year: 2008. Available from http://www.wri.org/publication/aqueduct-global-maps-20.

11. Forest change

Global Forest Change 2000–2013 database,[a] available from University of Maryland, Department of Geographical Sciences at http://earthenginepartners.appspot.com/science-2013-global-forest/download_v1.1.html.

12. Further sources

Other sources for free online geographic information and tools include, among many others, the GeoNetwork — Open Source (http://geonetwork-opensource.org/); the National Aeronautics and Space Administration (NASA) Earth Observing Data and Information System (EOSDIS) (https://earthdata.nasa.gov/); the NASA Prediction of Worldwide Energy Resource (https://earthdata.nasa.gov/); DIVA-GIS (http://www.diva-gis.org/Data); and Natural Earth (http://www.naturalearthdata.com/).

[a] See M. C. Hansen and others. High-Resolution Global Maps of 21st-Century Forest Cover Change. *Science*, vol. 342, No. 6160 (November 2013).

ANNEX III

Structure of the nexus assessment workshops

First workshop at the basin level

1. Introduction of the nexus and relevant explicatory examples (by the analysts).
2. Distribution of the opinion-based questionnaire.
3. Introduction to the key sectors, their main characteristics and issues by selected speakers.
4. Presentation of national sectoral policies by relevant authorities, as well as relevant national strategies and targets that may affect the basin.
5. Focus on the basin. Discussion on possible future development of the basin (river basin or aquifer management plan, infrastructure plans, sectoral targets, policy priorities etc.).
6. Illustration of possible interlinkages and nexus conditions. Explanation of the working group sessions.
7. First working group session on intersectoral mapping. Stakeholders are divided according to their area of expertise or work (land, water, energy, ecosystems). Each group identifies the most important interlinkages (impacts and trade-offs) associated with its component.
8. Joint prioritization of the key interlinkages to be considered in the assessment.
9. Presentation of official data on climate change and, if available, the predicted impact on the basin.
10. Second working group session on future dimensions. Participants are divided into mixed groups to define a few relevant scenarios and discuss how the key interlinkages will change under those scenarios.
11. Discussion on synergetic actions for the identified nexus conditions, by means of measures, policies, coordination arrangements and techno-economic solutions. Reflection on the transboundary dimension. Discussion on the benefits and limitations. Identification of who/which actors could advance the actions.
12. Discussion on indicators and sources available.
13. Presentation (by analysts) of some key findings or results from the workshop and the preparatory work, in the form of nexus graphs and storylines that will be analysed further and included in the basin assessment.
14. Presentation of next steps in the assessment.

Second workshop (for review of a draft nexus assessment report)

1. Presentation of findings and solutions.
2. Discussion on how the findings and solutions relate to policies or programmes in the countries and what could be done to address the identified intersectoral issues.

ANNEX IV

Template for presentations by national representatives

National development plans and sectoral goals in the river basin

1. State → Basin

National targets and goals to be achieved:

(a) Food security;
(b) Energy security;
(c) Water security.

National policies and action plans for:

(a) Poverty alleviation;
(b) Environmental protection;
(c) Climate mitigation and adaptation;

2. Basin → State

List of key sectors in the basin (such sectors have to be key from the country's perspective, in the context of the basin). For example:

(a) Large-scale plantation of a certain crop (agriculture);
(b) Extractive industry.

List of sectors that could play a bigger role in the economy of the basin (high potential from the country's perspective). For example:

(a) Wind power production;
(b) Tourism.

3. Regional development programmes involving the key sectors in the basin

4. Implementation measures (for instance, incentives or other economic benefits to promote specific sectors)

General notes:

(a) Wherever possible, refer to quantitative and/or spatial information (e.g. irrigated land expansion: X number of hectares);
(b) Include a list of sources (policy, documents, website pages) to which the presentation refers.

ANNEX V

Guide to the governance analysis

1. The governance analysis of a nexus assessment looks at the legislative, institutional and policy framework of the basin, the countries and the region by analysing:
   (a) The institutional structure of water, energy, agriculture and ecosystems at the local, national, basin, transboundary and regional levels;
   (b) The legislative framework;
   (c) Measures and policy instruments to implement sectoral strategies at the national level;
   (d) Economic instruments;
   (e) The level of coordination and coherence among sectors and countries.
2. The governance analysis will help address the following questions:
   (a) Where does the institutional framework lack coherence (e.g. gaps or overlaps of responsibilities, diverging objectives)?;
   (b) What are the potentially conflicting objectives of sectoral policies, including shortcomings in the regulatory basis, administrative practice and the administrative philosophy that may present obstacles to the resolution of such conflicts?;
   (c) Does the implementation of measures and regulations have the desired effect from a sectoral point of view? Does a nexus (intersectoral) point of view highlight the need to change them or to better coordinate them?;
   (d) What opportunities are there for administrative cooperation, dispute resolution, expert input, the participation of stakeholders, etc.?;
   (e) What is the scope of transboundary cooperation in relation to resource uses in the basin, and what aspects may hinder it? Can transboundary cooperation help to address the issues identified and, if so, how?
3. While governance analyses commonly also highlight the importance of political differences and power asymmetries, these factors were not specifically considered in the nexus assessment.
4. The questions set out in the following sections are meant to help the analyst in undertaking a governance analysis. In order to evaluate measures — from their coherence at an institutional level to their actual implementation — the questions are divided into four groups: institutions; sectors and policies; implementation (including economic instruments and legislation); and incentives and safety nets.

Institutions

5. When looking at institutions, it will be useful to ask:
   (a) What are the institutions at the local, national, basin, transboundary and regional level governing the use of water, energy and land resources?;
   (b) Which institutions protect the ecosystems and the functioning of the services they provide?;
   (c) What type of institution(s) are there?;
   (d) Are their mandates coherent (e.g. for a utility, to supply; for regulators, to establish prices and uses; separation of regulatory and operational functions, etc.)?;
   (e) Is there coordination or conflict between institutions — within a sector, between sectors, or between the national and local or the national and regional levels?;
   (f) Are there institutional arrangements in place to support intersectoral dialogue/cooperation?;
   (g) Are there mechanisms in place to solve conflicts related to suboptimal resource allocation?

Sectors and policies

6. For sectors and policies, the following should be considered:
   (a) What are the sectoral plans at the local, national, basin, transboundary and regional level for?:
      (i) General: priorities for economic developments and (if applicable) reduce poverty;
      (ii) Energy production and distribution (also for export);
      (iii) Greenhouse gas mitigation and adaptation;
      (iv) Water supply, sanitation and wastewater treatment facilities;
      (v) Agriculture, irrigation plans, significant shifts to new crops or agro-industry type (also for export);
      (vi) Ecosystems protection and support (including flood protection);
      (vii) Expected/planned economic development in the region (including tourism);
   (b) What are the sectors prioritized in policy?;
   (c) Is there integrated planning (centralized/decentralized)? If too decentralized, how are significant plans taken into account in the activities of municipalities (coherence)? If too centralized, how can optimization be achieved locally?

Implementation (including economic instruments and legislation)

7. It is important to differentiate between countries in which a market economy is predominant and where State regulation is the main engine for change. In both cases, legislation is important although its extent may differ, but in the former case the application and relative significance of economic instruments is typically greater. The role of the market and economic instruments in the allocation of resources in particular is more prominent in market economies. So some important questions to ask are:
   (a) What are the main incentives, regulations/legal requirements and standards aiming at protecting the environment?;
   (b) Is the legal basis adequate (e.g. ownership of resources, users rights, uses)?;
   (c) Pricing of energy and water. What are the market or allocation rules behind the pricing of these resources? How does this vary from sector to sector?;
   (d) Allocation:
      (i) How is land allocated? Are there many small farmers or large plantations? Are they formal or informal?;
      (ii) How is water allocated to the different sectors? In particular, does the agricultural sector and/or the energy sector particularly benefit from national policies?;
   (e) Are environmental assets related to the basin valued as economically significant? How is that value translated into policy?;
   (f) Are the economic sectors (resource users) simply in conflict with environmental protection actors or there is some kind of collaboration (e.g. eco-tourism or bio-agriculture)? If yes, at which level?;

(g) With regard to the energy sector, is there specific legislation governing water/ land uses by the energy sector (e.g. environmental flows, legislation on chemical/ thermal pollution, environmental impact assessment requirements for the installation of renewables)?;

(h) What regulations are there on resources use: water (treatment requirements, discharges, etc.), energy (efficiency), land (allotments, deforestation, etc.)?

Incentives (to reduce impact and improve efficiency) and safety nets

8. When analysing measures and instruments, it is important to include the point of view of the farmer (or cooperative, etc.), water and energy utilities, the private sector (e.g. industry). To this end, it will be useful to ask:

   (a) How are the above-mentioned actors governed, and what are the incentives for them to efficiently use resources and limit their impact? Do existing incentives work?;

   (b) Are inputs (resources) regulated? Are outputs regulated and, if so, how?;

   (c) How are economic activities supported (e.g. reduced taxation, subsidy, rations and fixed tariffs)? What institution oversees the implementation of the incentives? In particular:

      (i) Subsidies to agriculture. How much does water cost to farmers and how is it provided (e.g. fixed connection or ration)? Are fertilizers, machinery, etc., accessible at convenient prices? Are the incentives directed at specific crops (is growing certain crops more beneficial than growing others)?;

      (ii) Are there significant subsidies for one energy source over another, that cause the poorest to overuse one resource or that avoid the exploitation of other resources?;

   (d) What are the mechanisms to ensure that tariffs increases, new technologies and new regulations do not hit the poorest shares of population?

Convention on the Protection and Use of Transboundary Watercourses and International Lakes
Environment Division
Economic Commission for Europe
Palais des Nations
1211 Geneva 10
Switzerland

E-mail: water.convention@unece.org
Website: www.unece.org/env/water

Reconciling resource uses in transboundary basins: assessment of the water-food-energy-ecosystems nexus

Coordination between the water, energy, food and environment sectors is fraught with difficulties even at the national level, but the complexity increases substantially in transboundary basins where the impacts spread from one country to another. The "nexus approach" to managing interlinked resources has emerged as a way to enhance water, energy and food security by increasing efficiency, reducing trade-offs, building synergies and improving governance, while protecting ecosystems.

This publication contains the results of nexus assessments that have been carried out in the framework of the UNECE Water Convention's programme of work for 2013–2015 in specific basin contexts: the Alazani/Ganykh in the Caucasus, the Sava in South-Eastern Europe and the Syr Darya in Central Asia. The assessments aimed to foster transboundary cooperation by identifying intersectoral synergies and determining measures that could alleviate tensions related to the multiple needs of the riparian countries for common resources. The process looked to generate relevant information to support decision-making, and it engaged diverse expertise and key actors in the basins.

The nexus assessments describe the characteristics of the resources of water, food and land, energy and ecosystem services, and their governance. Graphics illustrate the interlinkages identified. Climate change and socioeconomic drivers, and their effects on intersectoral dynamics, are also considered. Finally, a broad range of beneficial response actions are outlined. Such solutions to the nexus span institutions, information, instruments, infrastructure as well as international coordination and cooperation.

The methodology employed was developed specifically for assessing the nexus in transboundary basins with multi-disciplinary expertise and was applied with support from various partner organizations. It is applicable to diverse transboundary basins and aquifers, and its use is illustrated step-by-step. Lessons learned are shared for the benefit of those who wish to embark on a similar exercise.

Information Service
United Nations Economic Commission for Europe

Palais des Nations
CH - 1211 Geneva 10, Switzerland
Telephone: +41(0)22 917 44 44
Fax: +41(0)22 917 05 05
E-mail: info.ece@unece.org
Website: http://www.unece.org

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