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Solutions and investments in the water-food-energy-ecosystems nexus

A synthesis of experiences in transboundary basins

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SOLUTIONS AND INVESTMENTS IN THE WATER-FOOD-ENERGY-ECOSYSTEMS NEXUS: A SYNTHESIS OF EXPERIENCES IN TRANSBOUNDARY BASINS

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FOREWORD

Understanding the interlinkages between food and energy production, water and the ecosystems improves the capacity to anticipate and minimize negative trade-offs and opens cross-sectoral cooperation opportunities at national and transnational levels in transboundary basins. This is the essence of the nexus approach which serves to reconcile the multiple uses of these resources and to reduce related tensions.

Work on the water-energy-food-ecosystems nexus under the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) started in 2013, with the development of a methodology to analyse cross-sectoral linkages – essentially resource management trade-offs and synergies — in transboundary settings in order to facilitate cooperation. The Task Force on the Water-Food-Energy-Ecosystems Nexus was established to guide application of this methodology.

The methodology has since been used in close cooperation with national administrations to assess six transboundary river basins and one shared aquifer, leading to the establishment of partnerships promoting cross-sectoral, transboundary cooperation in different contexts.

As transboundary nexus dialogues and assessments have the potential to provide concrete solutions and extend investments, it is timely to take stock of the experience accumulated so far in countries and basins around the world. The analysis presented in this publication draws on 36 nexus case studies from specific basins in Europe, Asia, Africa and the Americas. The findings demonstrate the added value of this form of cooperation, highlighting implementation challenges and providing possibilities for future development.

The publication also provides important policy considerations related to the financing of cross-sectoral investments, and addresses managers and policymakers in the fields of water and the environment, energy and agriculture, finance and the economy, as well as actors engaged in transboundary water cooperation and conflict prevention.

As this publication shows, transboundary and regional cooperation play a crucial role in the development of solutions and investments, building on existing synergies in natural resources, improving the coherence and effectiveness of cross-sectoral policy action, especially in relation to climate and the environment, and providing multiple benefits such as increased quality and sustainability in accessing water and energy. Actual implementation of these solutions and investments also requires effective cross-sectoral cooperation in and across other scales – urban and local, sub-national and national, and global.

Multi-level coordination and cooperation is essential to implementing the Agenda 2030 for Sustainable Development and to addressing global challenges related to climate change, widespread ecosystem loss and increased resource insecurity, and to manage the impact that these have on the socio-economic, health and environmental conditions on the ground.

The United Nations Economic Commission for Europe (ECE) promotes the application of the nexus approach to cooperation at different levels through relevant tools and instruments such as Conventions and standards. The work of the ECE Nexus Cluster on the "sustainable management of natural resources" supports countries in the design and implementation of integrated policies that address current and future challenges.

Finland, which leads the Convention's work on the water-energy-food-ecosystems nexus, is able to draw on perspectives linked to its unique resource base in order to apply integrated approaches to managing natural resources and promote nexus thinking. It is our hope that this publication will inspire the development and implementation of a greater number of cooperative solutions and joint nexus investments in transboundary basins around the world.

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[1] UN Security Council Resolution 1244

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ACRONYMS AND ABBREVIATIONS

3S	Sekong, Sesan and Srepok
ABAKIR	Lake Kivu and Ruzizi River Basin Authority
ACMAD	African Centre of Meteorological Application for Development
ACTO	Amazon Cooperation Treaty Organization
ADB	Asian Development Bank
AGRHYMET	Regional Centre for Agriculture, Hydrology, Meteorology, Niger
AICS	Italian Agency for Development Cooperation
ALT	Authority of Lake Titicaca
ASEAN	Association of Southeast Asian Nations
BAU	Business as usual
BRIDGE	Building River Dialogues and Governance
CAMIS	Coordinated Activities for Management of Isonzo – Soča
CAP	Common Agricultural Policy
CAREC	Regional Environmental Centre for Central Asia
CEDEAO	Economic Community of West African States
CEPAL	United Nations Economic Commission for Latin America and the Caribbean
CGIAR	Consultative Group on International Agricultural Research
CNVP	Connecting Natural Values and People Foundation
DAF	Decision Analytical Framework
DAFNE	Decision Analytic Framework to explore the water-energy-food Nexus
DG INTPA	Directorate-General of International Partnership
DRB	Danube River Basin
EBRD	European Bank for Reconstruction and Development
EC	European Commission
ECE	United Nations Economic Commission for Europe
ECLAC	United Nations Economic Commission for Latin America and the Caribbean
ECPDM	European Centre for Development Policy Management
EE	Energy efficiency
EIB	European Investment Bank
ESCWA	United Nations Economic and Social Commission for Western Asia
EU	European Union
EUSDR	EU Strategy for the Danube Region
FASRB	Framework Agreement on the Sava River Basin
GAS	Guarani Aquifer System
GCF	Green Climate Fund
GEF	Global Environment Facility
GIZ	German Agency for International Cooperation
GMS	Greater Mekong Sub-region
GWP	Global Water Partnership
GWP-Med	Global Water Partnership Mediterranean
HPP	Hydropower plant
IADB	Inter-American Development Bank

IBRD	International Bank for Reconstruction and Development
ICA	Infrastructure Consortium for Africa
ICEM	International Centre for Environment Management
ICPDR	International Commission for the Protection of the Danube River
IFC	International Finance Corporation
IFI	International finance institutions
ISRBC	International Sava River Basin Commission
IUCN	International Union for the Conservation of Nature
IW:LEARN	International Waters Learning Exchange and Resource Network
IWA	International Water Association
IWRM	Integrated Water Resource Management
JbW	Joined by Water
JRC	Joint Research Centre
LAC	Latin America and the Caribbean
LACC	Lake Chad & Adaptation to Climate Change
MENA	Middle East and North Africa
MPWI	Multi-Purpose Water Infrastructure
MOU	Memorandum of Understanding
MRC	Mekong River Commission
MSIOA	Multi-Sector Investment Opportunity Analysis
NAP	National Action Plan
NBA	Niger Basin Authority
NDC	National Determined Contributions
NGO	Non-governmental organization
NEHAP	National Action Plan for Environment and Health
NREAP	National Renewable Energy Action Plan
NWSAS	North Western Sahara Aquifer System
OECD	Organisation for Economic Co-operation and Development
OMVS	Senegal River Basin Development Organization
OP	Operational Plan
OSCE	Organization for Security and Co-operation in Europe
OSS	Observatory for Sahara and the Sahel
PDP	Power Development Plan
PID	Project Information Document
PES	Payments for Ecosystem Services
RBO	River Basin Organization
RCC	Regional Cooperation Council
RET	Renewable energy technologies
SADC	Southern Africa Development Community
SAP	Strategic Action Programmes
SAWRU	State Agency for Water Resources of Ukraine
SDG	Sustainable Development Goal
SEA	Strategic Environmental Assessment
SDIP	Sava and Drina Rivers Corridors Integrated Development Programme
SPECA	United Nations Special Programme for the Economies of Central Asia

TDA	Transboundary Diagnostic Analyses
TEN-T	Trans-European Transport Network
UFM	Union for the Mediterranean
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
WASH	Water, Sanitation and Hygiene
WEF	Water, Energy, Food
WEFE	Water, Energy, Food and Ecosystem
WEN	Water-Energy Nexus
WEPS-NENA	Water efficiency, productivity and sustainability in the Near East and North Africa regions
WISE-UP	Water Infrastructure Solutions from Ecosystem Services
WWF	Worldwide Fund for Nature
WWTP	Waste Water Treatment Plant

Units of measure

CO_2	Carbon dioxide
GW	Gigawatt
km^2	Square kilometre
m^3	Cubic metre
MW	Megawatt
MWh	Megawatt-hour

EXECUTIVE SUMMARY

More effective cross-sectoral "nexus" cooperation would improve the sustainable management of natural resources in transboundary basins. Such cooperation would help reconcile the multiple uses of water resources – including agriculture, energy, domestic and industrial supply, and environmental needs – and benefit land resources, while positively impacting the status of shared waters. Following the formulation of the water-food-energy-ecosystem "nexus" concept, two core objectives quickly emerged: to guarantee coherence in implementation of the 2030 Agenda for Sustainable Development, and to provide "out-of-the-water-box" solutions to water management challenges in transboundary basins around the world.

This publication takes stock of accumulated experience, especially within water institutions, on the design, implementation and financing of nexus solutions to address common water and environment challenges in transboundary basins. Several water institutions have led or participated in cross-sectoral nexus dialogues, while others have designed and implemented plans and projects aimed at reconciling multiple uses of resources, reducing negative trade-offs and increasing synergies across sectors. Some of these multi-stakeholder dialogues were carried out within the framework of the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention), under the guidance of a dedicated Task Force on the Water-Food-Energy-Ecosystems Nexus.

The findings presented in this publication emerge from a stocktaking of nexus solutions from around the world, which all involve cross-sectoral cooperation and have transboundary relevance. The accumulated experience is drawn from basin-level case studies and regional dialogues of transboundary relevance in Africa, Asia, the Americas and Europe. The solutions considered in this study, while not always explicitly labelled "nexus", range from international and transboundary cooperation, to governance, economic and policy instruments, infrastructure and innovation. Moreover, all are implemented on the basis of cooperation among the broad water, agriculture and land, energy and ecosystem sectors, sometimes involving other sectors such as industry, tourism and navigation.

This publication provides a valuable knowledge base for designing and operationalizing nexus solutions and investments, and includes consideration of factors that contributed to their successful implementation and the challenges encountered. The insights from the stocktaking exercise aim to help governmental authorities and other actors better understand the potential of the nexus approach and to take the next steps. They can be particularly useful where intersectoral solutions have been identified but their operationalization is proving to be a challenge. Implementation of these solutions has the potential to address transboundary basin challenges, especially where water authorities engage effectively with economic sectors.

The experiences presented in this publication are the result of a stocktaking exercise consisting of a survey and a literature review complemented by inputs from expert consultations and a review of regional nexus dialogues. The ad-hoc survey was carried out in 2020 and involved stakeholders from different countries and river basins. Of the 36 case studies considered, 21 were drawn from the survey and 15 came from the literature review. The case studies were analysed to draw preliminary conclusions on common features and trends related to problems and solutions, financing sources and schemes, obstacles to implementation and enabling factors, as well as perceived added value and benefits.

Nexus solutions tackle a variety of issues related to water quantity, water quality and environment. The case studies drawn from the survey and literature review – which mostly reflect the experience of water institutions – indicate a higher incidence of solutions applied to address issues related to water quality and environment rather than water quantity (i.e. availability and variability). However, further consultations with experts and the experiences gathered from regional dialogues indicate that nexus solutions are also being developed to solve water quantity-related problems. In particular, the application of a nexus approach is sometimes supported by regional organizations (notably river basin organizations) and international financing institutions with the aim of improving coherence in multi-sectoral water investment planning.

According to the survey, the highest-ranking root cause of these issues is "anthropogenic changes in hydrology". Other root causes reported consistently in the survey are climate change, data and information limits, poor land use and management, land use change, poor intersectoral coordination, poor water resource management, inadequate finance and inadequate institutional capacity. Determining the root causes of problems in transboundary basins is a prerequisite to applying any solution. The creation of nexus dialogues can also take policymakers a step further by helping them to act upon these problems. This may involve adjusting policies and revising regulation, both of which require time and effort but are ultimately necessary to ensure coherence towards sustainable development.

Stronger transboundary cooperation ranks highest among enabling factors for the implementation of nexus solutions. Other factors include data and information sharing; increased awareness of options and benefits for cross-sector, transboundary trade-offs, compromise and synergies; and innovative operating rules for infrastructure among many others. Challenges that arise during implementation include: political obstacles, data and information shortcomings, inadequate institutions, financial constraints, persistent policy/sector silos, limited technical capacity, and limited time frames and options for benefit sharing.

Transboundary and regional nexus dialogues focus increasingly on the development of joint action. In general, these dialogues are informed by technical studies that address cross-sectoral impacts and the implications of development and climate change. However, despite differences, these dialogues ultimately aim at the operationalization of nexus solutions and investments. Examples also exist of international financial institutions assisting countries with the analysis of nexus dynamics in order to prioritize or review projects, taking into account their cross-sectoral and transboundary impact, and proposing sustainable financing schemes that involve nexus sectors.

By increasing the efficiency of natural resource use, nexus solutions can provide both economic and non-economic benefits (e.g. peace and stability). However, lack of specificity or evaluation of these benefits may prevent the development of concrete cross-sectoral projects. In fact, the respondents to the survey perceive the added value of a nexus approach as relating to the effectiveness of institutions in managing basin issues, rather than to the delivery of these benefits. However, these benefits should be spelled out. In transboundary basins, where investments are generally associated with high risk, the elaboration of transboundary and cross-sectoral arrangements based on shared benefits may increase the prospects of funding opportunities.

Nevertheless, there are clear ways to promote the uptake and upscaling of nexus solutions and investments in transboundary basins, notably basin-level action plans, coordinated strategies and investment plans, and even specific projects. In general, as the study shows, cross-cutting regional strategies agreed by multiple governments, river basin plans developed jointly by the riparian states and regionally coordinated support from financial institutions can be important vehicles for the joint prioritization and implementation of coordinated nexus solutions and investments.

In principle, the nexus approach could help catalyse co-financing for water and environment services from other sectors and private actors; however, there is a lack of evidence that this is happening. At present, the majority of financial resources used to implement nexus solutions come from the state (including donor financing), despite recognition that the nexus approach opens up clear opportunities for more private and blended finance though "green" investments in agriculture, energy, tourism and so on. The study also provides examples which show clearly that financing institutions are also concerned with the coherence of multiple projects in transboundary basins.

Nexus solutions and investments developed locally or at national level – and therefore not reflected significantly in this stocktaking exercise – do not necessarily provide transboundary benefits. For this to occur, solutions need to build on common understanding and mutual trust. The mobilization of new financial resources can provide an important stimulus for cooperation, directly overcoming financial constraints and indirectly improving the technical capacity of institutions to plan "bankable" solutions involving different sectors. However, no nexus solution can be identified or implemented without greater coherence of policy action and plans, which encompass political dialogue, adequate institutional/governance frameworks and structures, better information, and the search for common objectives, synergies and possibilities for benefit sharing.

Opportunities for nexus investments with transboundary benefits may arise from coordination and partnering across sectors and borders, with the support of regional organizations and through alignment with regional strategies for development. As political will is crucial to benefit from these opportunities, it is essential to convince high-level policymakers as well as non-line ministries (e.g. finance and economy) of their merits. The COVID-19 pandemic and recovery process have already prompted some review of programming frameworks, and the space for transboundary and multisectoral actions and investments could be further enlarged, with a view to exploring innovative financing approaches.

Cooperation is particularly important to reduce the risks around investments of regional importance and in transboundary contexts. Ultimately, the political will to coordinate and cooperate to achieve long-term sustainability (economic, environmental and social), including in relation to concrete multi-project schemes, will reassure investors, especially private ones who need structured financing schemes and can help closing financial gaps. The delivery pathway is also important. Based on the study, for example, there seems to be a correlation between infrastructural investments and adaptable programmatic financing, where funds are allocated to a programme (e.g. modernization of irrigations systems in a river basin) without connection to a specific project.

Where they exist, river basin organizations play a key role in facilitating or even catalysing nexus solutions and investments. By coordinating with other regional organizations, such as economic commissions, organizations for energy integration and so on, RBOs can facilitate the cross-sectoral dialogue needed to develop water infrastructure (grey and green), or other measures including information sharing in shared basins. Their contribution can be vital to the development of master plans that are "nexus proofed". However, much depends on their institutional structure and mandate, the availability of resources and capacity, as well as the willingness of countries to use these platforms to discuss strategic policies and investment plans.

Water management and environment policymakers can use nexus solutions and investments to act upon cross-cutting issues in cooperation with other sectors. Nexus solutions can help tackle environmental issues such as pollution, climate change and biodiversity loss in a more effective manner that involves all concerned stakeholders. Moreover, the nexus approach opens up an opportunity to leverage finance for investments in water and the environment, although there is a need for greater clarity about synergies, overlaps and trade-offs with other sectors' needs and interests, and to identify common ground for scoping proposals. Crucially, climate action documents (e.g. NDCs, NAPs) should include transboundary components and be linked to strategic basin-level documents (e.g. SAPs), which requires closer cooperation between water and climate action programming.

Energy and agriculture are the main water users and need to adopt a more proactive role in proposing solutions and investments that integrate water and environmental considerations. Efforts to ensure effective management of risks – which may relate to competing water and land use needs from other sectors – will benefit from early stage consultation and coordination with water and environmental authorities. This approach helps to avoid delays and controversy at later stages in the process. Innovative energy and agriculture/forestry solutions have great potential to generate cross-sectoral benefits, and even when immediate co-financing opportunities do not arise, efficiency and sustainability solutions in project design can translate into economic benefits over the long term. Conversely, uncoordinated actions to address specific problems may fail to resolve the issues at stake at larger scale. For this reason, it is crucial to evaluate sectoral policies and investment plans against their contribution to national and regional objectives, in order to increase resource security and sustainability, and to consider development alternatives, trade-offs and transboundary issues early on in the process.

Beyond water, energy and agriculture, nexus solutions and investments should be promoted by finance, economy and other non-line ministries. Water and the environment may rank low among the priorities of countries compared to energy and agriculture, despite the fact that water as a resource and provider of healthy ecosystems is fundamental to all economic activities and social wellbeing. The nexus approach can be helpful to design integrated packages of investments that optimize the available financial resources in order to achieve multiple sustainable development objectives at the same time, and – by virtue of their broader scope – become eligible for more funding sources. According to this study, programmatic funding seems an efficient way to mobilize public funding and private financing for infrastructural investments (especially if basket funding modalities are possible), circumventing the hazards cited by both the public and private sectors with respect to financing water sector infrastructure.

Innovative financing solutions involving private funding have a major role to play in upscaling nexus solutions in transboundary basins, but they need to be backed by high-level political commitment. Today, public funding (including from donors) is the main source of nexus investments of transboundary value. However, the nexus approach also opens up financing opportunities from the private sector, with prospects for designing innovative schemes that leverage these private investments. Furthermore, cross-sectoral cooperation can be crucial to access climate and environmental funds. At present, this potential is only minimally utilized in transboundary basins where more stakeholders need to be involved. However, the political commitment to coordinate investments could reduce the perceived risk of investors and unlock new resources. Such engagements by co-riparian states can reinforce transboundary cooperation, allowing progressively more ambitious joint projects to be negotiated and undertaken. Transboundary cooperation agreements and basin organizations could also be used to facilitate the implementation of innovative financing solutions.

Nexus solutions and investments can promote transboundary water cooperation and conflict prevention. Understanding the interlinkages between water, energy, land/food and environmental resources can create crucial opportunities to generate cooperation benefits or reduce tension. Insights about nexus issues and solutions can help devise actions that reduce pressure on shared water resources, both surface and groundwater, by acting on economic sectors that use water or have an impact on water resources. Hence, a nexus approach can help uncover unconventional solutions and alternative courses of action for water management and resolve allocation disputes. At the basin level, trade relations influence how resources are used, how their potential is exploited and how the related benefits are shared. Going further, nexus solutions may play a significant role in building trust and conflict prevention, provided that international water law principles are respected.

BACKGROUND

In 2012, the sixth session of the Meeting of the Parties to the Water Convention made a decision to incorporate into the work programme for 2013–2015 a series of assessments of the water-food-energy-ecosystem nexus in a representative set of transboundary basins. The Meeting of the Parties also decided to establish a Task Force on the Water-Food-Energy-Ecosystems Nexus to oversee these thematic "nexus" assessments. A methodology was developed for participatory assessment and then piloted and applied in the first basin assessments. In practice, this involved analysis and intersectoral transboundary dialogue about trade-offs and synergies in managing water and other natural resources (i.e. energy, land and food, and ecosystems).

In 2015, the seventh session of the Meeting of the Parties agreed to prepare a synthesis report of this methodology for dissemination to partners and for application in other basins worldwide. The conclusions and recommendations from the basin assessments were also circulated. Further basin assessments were prepared between 2016 and 2021, including an aquifer assessment, in order to provide additional insights into intersectoral issues. In parallel, the methodology was refined, with a focus on governance and participatory approaches. Additionally, a global stocktaking workshop organized with partners in 2016 led to the publication two years later of the report *Methodology for Assessing the Water-Food-Energy-Ecosystems Nexus in Transboundary Basins and Experiences from its Application: Synthesis*.

In 2018, the eighth session of the Meeting of the Parties asked the Secretariat to prepare a further synthesis report to demonstrate the value of applying a nexus approach to natural resource management in transboundary basins for presentation at the ninth session of the Meeting of the Parties (29 September – 1 October 2021).

In response to this request, the Secretariat carried out a stocktaking exercise over 2020/21 in cooperation with the International Union for the Conservation of Nature (IUCN) to gather experience about nexus solutions and investments. The exercise drew on the experience of stakeholders involved in the participatory nexus assessments carried out under the Water Convention and dialogues facilitated through the IUCN Building River Dialogues and Governance (BRIDGE) project. Both initiatives focus on transboundary basins. The stocktaking exercise included case studies with a broad geographical distribution.

The stocktaking exercise and the development of this synthesis report were overseen by the Task Force on the Water-Food-Energy-Ecosystems Nexus under the leadership of Finland. The sixth meeting of the Task Force (22–23 October 2020) discussed preliminary results as well as the main factors of success and obstacles to the implementation of nexus solutions and investments. The participants also discussed progress in applying nexus solutions and facilitating nexus dialogue at the regional level. Opportunities to finance projects and measures of an integrated or multi-sectoral character ("nexus solutions") with transboundary benefits were presented to the Task Force and related experiences were shared. The present synthesis report also integrates further experiences gathered from expert consultations and nexus dialogues in Latin America and the Caribbean and the Western Balkans.

This publication is aimed primarily at national, regional and basin institutions whose mandate covers water and the environment. However, the findings are also relevant to policymakers and stakeholders from productive sectors (notably energy and agriculture), non-line ministries (e.g. finance and the economy), non-governmental and intergovernmental organizations, and academia.

1. INTRODUCTION

1.1 Nexus dynamics in transboundary settings

Transboundary water resources account for over 60 per cent of global freshwater flows.[2] Water, energy, food, and environmental security depend on these waters. However, demographic, economic, social, and climatic changes are exerting increasing pressure on natural resources, including through ever-growing energy, food, and water demands that threaten the well-being of ecosystems. To achieve more balanced and sustainable use of natural resources, strategic decisions must be taken to ensure they are better valued and more responsibly managed.

Choices related to the management and use of energy, land and water are typically taken in isolation and without adequate consideration of the inter-sectoral implications of planned developments, either positive or negative. This can result in painful inter-sectoral trade-offs and may also discourage collaborative solutions – both in developing and developed countries.

In transboundary settings, not addressing trade-offs and externalities may provoke friction and reduce trust between countries, thereby hindering regional development and potentially generating conflict. Conversely, a nexus (or cross-sectoral) approach to managing common resources could greatly enhance water, energy and food security in riparian states, including by increasing resource use efficiency, capitalizing on regional complementarities and improving natural resource governance.

The nexus concept is rooted in the idea that more coherent sectoral and national policies will reduce resource management trade-offs and reconcile multiple uses of resources, including transboundary waters. Policy coherence can be achieved through intersectoral exchange or communication, active coordination and due consideration

[2] UN-Water, Transboundary Waters: Sharing Benefits, Sharing Responsibilities (United Nations, Geneva, 2008).

of different interests, negotiation of trade-offs, exploration of synergies and cooperation towards common objectives. Policy coherence is a necessary condition for effective climate action, water and food security, ecosystem preservation and development in general, all of which requires acting across sectors (energy, food, biodiversity, etc.) and scales (global to local and transboundary).

The 2030 Agenda for Sustainable Development also requires coordination across sectors, coherent policies and integrated planning – all of which constitute a "nexus approach". Use of natural resources in transboundary basins has been identified as a fundamental priority for achieving the 2030 Agenda and the 17 Sustainable Development Goals (SDGs).[3]

Policy coherence could also bring economic benefits by facilitating the development of synergies and partnerships, and in turn generate more opportunities for multi-sectoral co-financing of investments – both public-private and multi-country. In transboundary settings, increased trust and cooperation, including through agreements among riparian states, is essential to reduce the political risks for investors. Climate action, the green economy and sustainable development provide valuable cross-sectoral policy frameworks for coordinated, integrated projects and can support water authorities in establishing strategic partnerships and finding financing.

Multiplying the benefits from a single project (e.g. through multipurpose infrastructure and combining innovative solutions to attain the efficient use of different resources) is the most practical way of contributing to different objectives at the same time. However, without a coherent policy framework and consultative processes and planning frameworks that support integration, the upscaling or replication of this type of investment is challenging. Cooperation frameworks such as transboundary water agreements, institutional arrangements and strategic action plans for basins could all play a positive role, provided that they create an effective basis for engaging with relevant economic sectors (e.g. industry, energy production, agriculture or tourism).

1.2 Why is this publication on nexus solutions and investments necessary?

A variety of governments and institutions have been involved in nexus dialogues and/or assessments (see Chapters 4, 5 and 6), amounting to a significant body of knowledge and practical experience. However, there remains a lack of convincing examples to demonstrate the clear added value of nexus approaches in policymaking and investment planning, as compared to traditional, sectoral approaches. This publication aims to fill this gap. The nexus approach should lead to nexus solutions that increase resource efficiency and reconcile different interests while protecting the environment and maximizing the social value of investments. However, there is no blueprint for the design and implementation of nexus solutions, and cross-sectoral cooperation that adopts a nexus approach is not always identified as such. Taking stock of nexus solutions requires considering a broad spectrum of experience and answering the following questions:

- What are the most common problems faced in transboundary basins tackled through a nexus or cross-sectoral approach?
- What are the most common categories or typologies of solutions and their related investments?
- What trade-offs and synergies are most common across sectors and countries?
- What benefits arise from cross-sectoral cooperation in transboundary basins and can be used for the purposes of communication and advocacy?
- What are the enabling factors for implementing solutions, especially institutional arrangements and financing frameworks?

Filling these gaps requires taking stock of the lessons learned from designing and implementing "nexus solutions" in transboundary contexts.[4]

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[3] UNECE, *Natural Resource Nexuses in the ECE Region* (United Nations, New York and Geneva, 2021).

[4] Report of the Meeting of the Parties on its eighth session (ECE/MP.WAT/54).

1.3 The Water Convention's nexus assessments and IUCN's BRIDGE project

This publication draws on the experience of UNECE and the International Union for the Conservation of Nature (IUCN) as well as that of key partner institutions involved in similar exercises of a cross-sectoral character and regional or transboundary relevance.

The nexus assessments carried out under the Water Convention included five transboundary river basins, the Alazani/Ganykh, the Sava, the Syr Darya, the Drina and the Drin, and one shared aquifer, the North Western Sahara Aquifer System (NWSAS), all of which were developed through a participatory process involving the concerned sector authorities and other key stakeholders (e.g. from regional coordination bodies, non-governmental organizations and academia).[5] The methodology developed under the Water Convention incorporates analysis of both technical and governance aspects of the nexus.[6] While the first set of assessments covered the Alazani/Ganykh, Sava and Syr Darya, and concentrated mostly on the joint identification of cross-sectoral issues, the most recent set covered the Drina, the Drin and the NWSAS, and focused more on nexus solutions. For example, the assessment of the NWSAS included the joint definition of a package of nexus solutions as part of the participatory process and also considered previous experience of implementing cross-sectoral action in the riparian states. The assessment of the Drin River Basin, the second phase of which is ongoing, provides a more detailed description of the implementation of certain cross-sectoral actions included in the Strategic Action Programme (SAP) of the basin.

The IUCN project Building River Dialogues and Governance (BRIDGE) helps build the capacities of countries sharing river or lake basins to implement effective water management arrangements through a shared vision, benefit-sharing principles, and transparent and coherent institutional frameworks. The goal of the project is to enhance cooperation among riparian states by applying water diplomacy at multiple levels. The BRIDGE project works through five key implementation strategies: (i) demonstrating the value of cooperation, (ii) learning (training and capacity building), (iii) dialogue, (iv) leadership (empowering champions), and (v) advice and support (provided on demand to governments and stakeholders). The project encourages cross-sectoral cooperation – in the case of the Sekong, Sesan and Srepok (3S) basin, specifically through the assessment of nexus trade-offs. The BRIDGE project also supports dialogue in Africa, Asia and Latin America.[7]

The regional experience from partners reflected in this publication also draws on other initiatives promoting transboundary and regional cooperation across sectors. These include the Nexus Regional Dialogues Programme, which is funded by the European Commission and the German Federal Ministry of Economic Cooperation and Development BMZ, and implemented by the German Agency for International Cooperation (GIZ), and several projects supported by the Global Environment Facility (GEF) International Waters Focal Area, which include the development of Transboundary Diagnostic Analyses (TDA) and Strategic Action Programmes (SAP).[8]

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5 All assessment reports are available on the UNECE website at: https://unece.org/environment-policy/water/areas-work-convention/water-food-energy-ecosystem-nexus.

6 UNECE, Methodology for Assessing the Water-Food-Energy-Ecosystems Nexus in Transboundary Basins and Experiences from its Application: Synthesis (United Nations, New York and Geneva, 2018).

7 The BRIDGE project description and the map of the basins are available at: www.iucn.org/theme/water/our-work/current-projects/bridge.

8 Information on the GEF International Waters is available at: www.thegef.org/topics/international-waters.

2. A FRAMEWORK FOR ANALYSING NEXUS SOLUTIONS

2.1 A dual-axis framework

According to terminology developed under the Water Convention, a *nexus solution* is "an intervention that would benefit more than one sector … including interventions that reduce the pressure on ecosystems (or the environment at large)". *Nexus investments* are investments that support the implementation of nexus solutions. In transboundary contexts these solutions have an impact, either direct or indirect, on shared water resources.

The analytical framework was developed[9] to capture the *implementation* of nexus solutions and related nexus investments of transboundary relevance where: "Nexus solutions and investments arise from silo-breaking action and directly or indirectly produce sustainable transboundary benefits in multiple, diverse water-using or water-dependent sectors in the riparian states".[10] The framework should support investigation of the questions presented in section 1.2 (see Annex 1). A tabular representation of this dual-axis framework is presented in Table 1.

The horizontal axis of the analytical framework presents typical problems that affect transboundary basins related to water quantity, water quality and environmental aspects. The vertical axis features underlying factors of success for four clusters of nexus solutions: (i) international/transboundary cooperation; (ii) governance, (ii) economic and policy instruments, and (iv) infrastructure (both grey and green) and innovation. The aptness and focus of the framework axes facilitate ease of use and enable users to link certain typologies of problems to specific categories of solutions. The framework also helps to identify key factors in the successful implementation of nexus solutions.

[9] The analytical framework was developed by Phil Riddell with input from IUCN and UNECE.

[10] Phil Riddell, *Taking Stock of Nexus Solutions and Investments in Transboundary Basins: A Synthesis* (unpublished, 2020). This publication includes the framework and analysis of replies to the survey under the Water Convention.

Table 1. The analytical framework

				Water-related problems																													
				Quantitative												Qualitative												Environmental					
				Permanent						Time based						Permanent						Time based											
				Too much water		Insufficient water		Excessive variability		Too much water		Insufficient water		Excessive variability		Pollution		Salinity		Turbidity		Pollution		Salinity		Turbidity		Biodiversity loss or compromise	Habitat loss or compromise	Sediment or erosion	Morphological change Compromised human health		
				Natural	Anthropogenic	Natural	Anthropogenic	Natural	Anthropogenic	Natural	Anthropogenic	Natural	Anthropogenic	Natural	Anthropogenic	Natural	Anthropogenic	Natural	Anthropogenic	Natural	Anthropogenic	Natural	Anthropogenic	Natural	Anthropogenic	Natural	Anthropogenic						
Solution categories	International cooperation	Success factors	Stronger transboundary cooperation																														
			Increased awareness of the benefits accruable to cross-sector transboundary trade-offs, compromise and synergies																														
			Increased awareness of options for cross-sector, transboundary trade-offs, compromise and synergies																														
			New, multi-purpose basin-level																														
	Governance		Multi-purpose use of existing infrastructure																														
			Shared data and information																														
			Common metrics																														
			Standardized social and environmental impact assessments between sectors and between riparian states																														
			Functional, transparent incentive structure																														
	Economic policy and instruments		Appropriate, well-enforced regulations																														
			Demand management policies																														
			Legal arrangements																														
			Institutional arrangements																														
	Infrastructure and innovation		Economically mobile water																														
			Transparent and equitable terms of transboundary trade between riparian states																														
			Multi-purpose infrastructure																														
			Innovative infrastructure																														
			Innovative financing																														
			Innovative infrastructure operating rules																														
			Natural infrastructure																														
			Small scale conservation agriculture																														
			Large scale conservation agribusiness																														
			Renewable energy																														
			Smart energy strategies																														
			Decentralized service delivery concepts																														
			Decentralized service infrastructure																														

Nexus solutions typically address compound problems (e.g. those related to both water quality and quantity) and/or combine two or more categories of solutions (e.g. governance and infrastructure), as explained below in section 2.3. Drawing conclusions from the collated experiences requires unpacking these different elements and recombining them according to the following common characteristics identified through the application of an ad-hoc survey (see section 2.4):

- problems in transboundary basins and their root causes
- categories of solutions and factors in successful implementation
- financing architecture of the solution
- perceived added value of a nexus solution (or missed opportunities where the solution was not implemented successfully)
- challenges related to the implementation of nexus solutions
- enabling factors for the implementation of nexus solutions (e.g. institutional arrangements and financing frameworks)
- trade-offs and synergies across sectors and countries
- benefits of cooperation across sectors and countries.

2.2 The water-related problems addressed

Typical water-related problems were identified through an examination of the literature, in particular transboundary diagnostic analyses (TDA) carried out around the world using the Global Environment Facility (GEF) methodology[11] between 1999 and 2018.[12] This approach anchored the nexus solutions to actual problems experienced by water institutions in transboundary basins. The outcome of this process was the development of a Problems axis to categorize the problems (see Annex 2 for more details). Table 2 presents the results of this process.

[11] GEF's TDA-SAP methodology is available on the website of the GEF International Waters Learning Exchange and Resource Network (IW:LEARN): https://iwlearn.net/manuals/tda-sap-methodology.

[12] Input from the GEF secretariat and in particular from the GEF International Waters Learning Exchange and Resource Network (IW:LEARN).

Table 2. Categorization of problems in the problems axis

Problem clusters				Notes
Primary	**Secondary**	**Tertiary**	**Quaternary**	
Water quantity	Permanent	Too much water	Natural	Not all floods are bad and not all flood prevention is good. The same is true of waterlogging. Ecosystems in seasonable rivers sometimes depend on dry conditions at certain times of the year.
			Anthropogenic	
		Insufficient water	Natural	Water scarcity is not necessarily a result of hydrological drought or climate change. It can also result from over allocation, unproductive use and limited economic mobility of water.
			Anthropogenic	
		Excessive variability	Natural	If due to natural causes, variability is only excessive in terms of water resource exploitation and management.
			Anthropogenic	
	Time based	Too much water	Natural	As above, but the related solutions may be different. Seasonal flooding may be crucial for basin welfare and may need to be restored.
			Anthropogenic	
		Insufficient water	Natural	
			Anthropogenic	
		Excessive variability	Natural	As above
			Anthropogenic	
Water quality	Permanent	Pollution	Natural	Pollution is not just a problem of effluent disposal or farm run-off. For instance, the adequacy of pristine adsorptive capacity may be compromised by anthropogenic means, in which case it is a quantitative issue, or it may have resulted from the drainage of wetlands. Natural pollution tends to accrue to intermittent events of a geological nature but is nonetheless included just in case.
			Anthropogenic	
		Salinity	Natural	Not all salinity is bad. The productivity of coastal wetlands and some terrestrial lakes can depend on high levels of salinity which can be compromised by anthropogenic means.
			Anthropogenic	
		Turbidity	Natural	Some rivers should be permanently turbid but no longer are due to the presence of dams. Equally, other rivers are supposed to have permanently low turbidity but do not because of poor land management in their catchments. Permanent changes in turbidity can have catastrophic effects on stream bed stability, healthy deltas, marine food chains beginning in sediment rich estuaries, infrastructure, etc.
			Anthropogenic	
	Seasonal/ time based	Pollution	Natural	This is unlikely to be relevant.
			Anthropogenic	Some pollution varies diurnally and not seasonally.
		Salinity	Natural	As above
			Anthropogenic	
		Turbidity	Natural	Natural turbidity cycles are essential for stream bed stability, healthy deltas and marine food chains.
			Anthropogenic	
Environment	Biodiversity loss or compromised			Although these issues may be caused by the problems listed above, they are included as stand-alone items due to their substantive character and because they may have nexus solutions of their own.
	Habitat loss or compromised			
	Sediment or erosion			
	Morphological change			
	Compromised human health			

2.3 Categories of solutions and factors for successful implementation

The categories of solutions were derived from the UNECE framework used for the nexus assessments under the Water Convention (as explained in Annex 3), with the aim of capturing all nexus solutions that tackle a problem of transboundary relevance by applying a nexus approach. This includes cases where a problem is solved indirectly, for instance through improved energy efficiency that contributes to water resource management by reducing water demand.

The development of the Solutions axis necessitated a process-oriented analysis to determine how the solutions were achieved and to identify the factor(s) that facilitated their design and/or implementation. This analysis was expedited by rearticulating the five categories proposed by UNECE as more discrete factors of success and regrouping them into four clusters: international/transboundary cooperation, governance, economic and policy instruments, and infrastructure[13] and innovation.[14] The success factors are described in Table 3.

[13] For the purpose of this study, infrastructure could mean natural or built. Natural infrastructure comprises investments in the conservation, adaptation or beneficial modification of natural landscape features – examples could be natural or artificial and include wetlands, reforestation, restored floodplains, catchment stabilization and so on. Built infrastructure is the multi-purpose, civil works infrastructure needed to attenuate or otherwise manage flooding and/or increase water security and water supplies for energy and food security (both production and livelihood based) and for the environment. It may comprise dams, reservoirs, water-harvesting facilities, facilities needed to increase the physical efficiency of water use, drains, re-use-recycling facilities and even inter-basin transfers.

[14] The five categories proposed by UNECE were: (i) Institutions, (ii) Information, (iii) Instruments, (iv) Infrastructure (and investment), and (v) International coordination and cooperation (referred to as the "5 I's"). Under the new categorization, the factors of success related to "Information" are incorporated into the other categories.

Table 3. Categories of solutions and success factors

Categories (or clusters) of solutions	Success factors
International cooperation	• Stronger transboundary cooperation • Increased awareness of the benefits accruable to cross sector transboundary trade-offs, compromise and synergies • Increased awareness of options for cross-sector, transboundary trade-offs, compromise and synergies • New, multi-purpose "basin" level infrastructure[15] • Multi-purpose use of existing infrastructure[16]
Governance	• Shared data and information • Common metrics • Standardized social and environmental impact assessments between sectors and between riparian states • Functional, transparent incentive structure • Appropriate, well-enforced regulations
Economic and policy instruments	• Demand management policies • Legal arrangements[17] • Institutional arrangements[18] • Economically mobile water[19] • Transparent and equitable terms of transboundary trade between riparian states
Infrastructure and innovation	• Multi-purpose infrastructure • Innovative infrastructure • Innovative financing • Innovative infrastructure operating rules • Natural infrastructure • Small-scale conservation agriculture • Large-scale conservation agribusiness • Renewable energy • Smart energy strategies • Decentralized service delivery concepts • Decentralized service infrastructure

2.4 Use of the framework

The analytical framework was populated with case studies of nexus solutions (and related investments) from the literature and a dedicated survey (see section 2.5). As the nexus solutions typically occupy more than one "cell" in the framework, drawing conclusions from the framework requires unpacking these different elements and re-combining them according to common characteristics. In visual terms, this means identifying which cells receive the highest number of "hits". Table 4 provides a hypothetical case study.

15 In the sense of cooperative development of infrastructure across border.

16 In the sense of coordinating across border.

17 In the sense of legal arrangements for demand management.

18 In the sense of institutional arrangements for demand management.

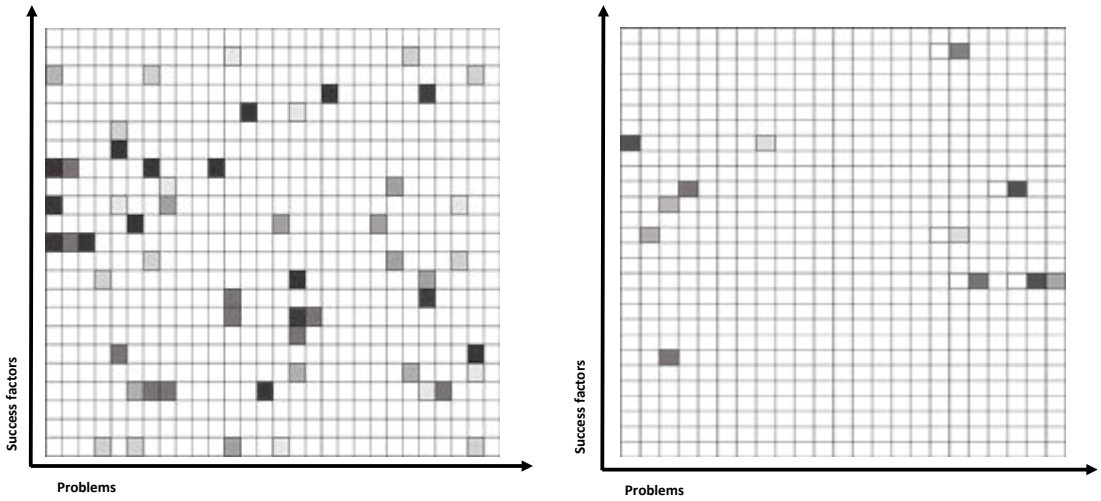
19 Water is economically mobile when the pertaining legal, regulatory and institutional framework allows it to be allocated to uses that reduce its opportunity cost which – simply stated – is the economic return of its most lucrative use minus its return on current use. Where water governance is strong, the need for economic mobility applies only to the water left over when societal and environmental needs are satisfied. Economic efficiency of water use at basin level is directly proportional to the economic mobility of water within the basin (see Cai and others, "Does efficient water management matter? Physical and economic efficiency of water use in the river basin", EPTD Discussion paper no. 72. International Food Policy Research Institute IFPRI (2011). Available at https://ageconsearch.umn.edu/record/16043).

Table 4. Diversity of problems and solutions

	Problems		Possible solutions		
	Too much water	Too little water	Governance	Policy instruments	Infrastructure
Natural	Intense rainfall events	Seasonality	New multi-purpose basin-level infrastructure and multi-purpose use of existing basin-level infrastructure optimized as a result of trans-sector governance and international cooperation	New multi-purpose basin-level infrastructure and multi-purpose use of existing basin-level infrastructure optimized as a result of appropriate economic policies, incentive structures and well-enforced regulations	Water, energy, agriculture and environmental security enhanced, basin-wide as a result of landscapes restored or transformed by appropriate agribusiness operations (natural infrastructure)
Anthropogenic	Watershed degradation	Overallocation			
	Dam cascades with uncoordinated operating rules	Inefficient use			
	Upstream flood defences that simply send concentrated floodwaters downstream				

The application of the analytical framework to the nexus case studies produces solution-based scenarios. Figure 1 presents two possibilities that illustrate extreme versions of these scenarios. If the populated framework looks like the *right image*, there are a limited number of successful nexus solutions and only a small number of different problems have benefited from a nexus approach. Alternatively, if the populated framework looks like the *left image*, a variety of solutions can solve a wide range of problems and many problems potentially have several nexus solutions. In each case, darker cells indicate that the factor in question has proven more effective at addressing a specific problem.

Figure 1. Extreme framework scenarios



2.5 The survey

In addition to the analytical framework, a survey questionnaire was developed to gather common problems and solutions for analysis though the framework, and to try and answer other questions that require further investigation (see section 1.2) regarding the most common trade-offs and synergies encountered, benefits of cooperation, and enabling factors for implementation, notably institutional arrangements and financing frameworks, as well as the perceived benefits of applying a nexus approach compared to conventional siloed sectoral planning.[20]

[20] Questionnaire available at the webpage of the 6th meeting of the Nexus Task Force under the Water Convention: https://unece.org/environmental-policy/events/6th-meeting-task-force-water-food-energy-ecosystems-nexus

3. THE STOCKTAKING PROCESS AND EMERGING TRENDS

3.1 The process

The first phase of the stocktaking exercise in 2020 used the survey questionnaire to gather the experiences of countries and basins stakeholders.[21] These were then processed using the analytical framework presented in Chapter 2.[22] Of the total of 36 case studies, 21 were submitted in response to the survey,[23] with the other 15 drawn from a review of the literature. The case studies from the literature review provided significantly less information than those synthesized from the questionnaire and, as such, were processed using the analytical framework (to identify common problems and solutions), but were not subjected to further analysis (to determine root causes, success factors, financing schemes, added value, etc.).

This stock of experience enabled preliminary conclusions to be drawn on the most common problems in transboundary basins currently being tackled through a nexus approach, the most common categories/typologies of solutions and related investments, and enabling factors for the implementation of solutions, in particular institutional arrangements and financing frameworks. To a lesser extent, the analysis enabled reflections on common trade-offs and synergies across sectors and countries, and the benefits of cooperation.[24]

The collected case studies come from all continents: Africa (11), the Americas (4), Asia (9) and Europe[25] (12) (Table 5), and differ in their cross-sectoral reach. Some of them include the broad sectors of water, food, energy and ecosystems, but others also extend to other areas, notably industry, tourism and navigation.

Table 5. Summary of analysed case studies

Ref.	Basin, continent	Case study
1	Mekrou,[26] Africa	From the survey
2	Drina, Europe	From the survey[27]
3	Aral Sea,[28] Asia	From the survey
4	Parana, Americas	From the survey
5	Zambesi, Africa	From the survey
6	Lake Titicaca, Americas	From the survey
7	Sekong, Sesan and Srepok (3S), Asia	From the survey
8	Lower Syr Darya, Asia	From the survey
9	Mekong – 1, Asia	From the survey
10	NWSAS – 1, Africa	From the survey[29]
11	Dneister, Europe	From the survey
12	NWSAS – 2, Africa	From the survey
13	Mekong – 2, Asia	From the survey
14	Niger, Africa	From the survey
15	Mekong – 3, Asia	From the survey
16	Kura, Asia	From the survey

21 The survey was established online by UNECE.

22 Phil Riddell, Taking Stock of Nexus Solutions and Investments in Transboundary Basins: a Synthesis (unpublished, 2020).

23 Some replies to the survey were excluded because they comprised multiple river basins, or concerned single sectors.

24 Preliminary results from the survey are also included in "Solutions and investments in the water-food-energy-ecosystems nexus: Preliminary findings from a synthesis of experiences in transboundary basins" (ECE/MP.WAT/WG.1/2021/6–ECE/MP.WAT/WG.2/2021/6).

25 "Europe region" here includes both Eastern and Western Europe.

26 The respondent only cited agriculture as the affected sector, but in the narrative environmental problems were also mentioned, so these have been included as the second nexus element.

27 See also: UNECE, Assessment of the Water-Food-Energy-Ecosystem Nexus and Benefits of Transboundary Cooperation in the Drina River Basin (United Nations, Geneva, 2017).

28 The respondent only cited environment as the affected sector, but in the narrative agriculture and energy problems were also mentioned, so these have been included as additional nexus elements.

29 See also: UNECE, GWP-Med, OSS, Reconciling Resource Uses: Assessment of the Water-Food-Energy-Ecosystems Nexus in the North Western Sahara Aquifer System (United Nations, Geneva, 2020).

Ref.	Basin, continent	Case study
17	Drin, Europe	From the survey[30]
18	Lake Atitlan,[31] Americas	From the survey
19	Danube, Europe	From the survey
20	Limpopo, Africa	From the survey
21	Incomati, Africa	From the survey
22	Zambesi, Africa	World Bank Multi Sector Investment Opportunity Assessment for the Zambesi. A study of options[32]
23	Kafue,[33] Africa	Itexi-Itexi and Kafue Gorge Dams. A combination of joint operating rules and remote hydrological sensing could restore annual floods to the socially, economically and environmentally important Kafue Flats in Zambia[34]
24	Orange-Senqu, Africa	Stabilization of the Southern African Water Tower aka the Lesotho Highlands. Two studies (EU and IUCN) suggested that appropriate large-scale agribusiness could contribute to water, food and energy security, watershed rehabilitation and economic growth[35]
25	Rhine, Europe	Multi-stakeholder cooperation in the Rhine Basin. A real case of institutional cooperation solving problems arising from pollution and competition for water[36]
26	Lake Geneva, Europe	Transboundary water cooperation in a "benefit cluster" – the case of the Canton of Geneva, Switzerland and France[37]
27	Pripyat, Europe	Identifying benefits to boost cooperation in the upper Pripyat River basin[38]
28	Alazani/Ganykh, Asia	An assessment of the intersectoral linkages to complement a benefit assessment in the Alazani/Ganykh River Basin[39]
29	Lake Peipsi, Europe	Identifying a variety of beneficiaries in the economically and environmentally sustainable Lake Peipsi area[40]
30	Elbe, Europe	Transboundary cooperation responses to catastrophic flooding in the Elbe Basin[41]
31	Rhine, Europe	Environmental benefits of transboundary water cooperation on the Rhine[42]
32	Sava, Europe	Cooperation in the Sava River Basin: post-conflict cooperation and confidence building-related benefits[43]
33	Teesta, Asia	Water-for-peace deals in the Teesta Basin[44]
34	Great Lakes, Americas	Governance benefits of transboundary water cooperation – the case of the North American Great Lakes[45]
35	Danube, Europe	The Danube's transnational monitoring system: harmonized data for joint planning[46]
36	Senegal, Africa	Economic benefits in the Senegal River Basin[47]

30 See also: Phase I and II of the Drin Nexus Assessment: www.gwp.org/en/GWP-Mediterranean/WE-ACT/Programmes-per-theme/Water-Food-Energy-Nexus/seenexus.

31 The case of Lake Atitlan (Guatemala) is not transboundary but was considered a good example of a nexus approach and was therefore included in the analysis.

32 IUCN, Increasing Returns on Investment Opportunities by Applying a Nexus Approach: Best Practice Nexus Case Studies (IUCN, Belgrade, 2019)

33 The case of Kafue river basin (Zambia) is not transboundary but was considered a good example of a nexus approach and was therefore included in the analysis.

34 ICA, IUCN and IWA, Nexus Trade-offs and Strategies for Addressing the Water, Agriculture and Energy Security Nexus in Africa (Geneva, 2015).

35 IUCN. Increasing returns on investment opportunities by applying a nexus approach. Best practice nexus case studies (IUCN, Belgrade, 2019)

36 Ibid.

37 UNECE, Policy Guidance Note on the Benefits of Transboundary Water Cooperation (United Nations, Geneva, 2015).

38 Ibid.

39 Ibid. See also: UNECE. Reconciling Resource Uses in Transboundary Basins: Assessment of the Water-Food-Energy-Ecosystems Nexus (United Nations, Geneva, 2015).

40 Ibid.

41 Ibid.

42 Ibid.

43 Ibid. See also: UNECE, Reconciling Resource Uses in Transboundary Basins: Assessment of the Water-Food-Energy-Ecosystems Nexus in the Sava River Basin (United Nations, Geneva, 2015).

44 Ibid.

45 Ibid.

46 Ibid.

47 Ibid.

The second phase in the stocktaking process included a review of the survey and a discussion on nexus solutions in different regions at the sixth meeting of the Task Force on the water-food-energy-ecosystems nexus (22–23 October 2020).[48] The meeting participants discussed the preliminary results, main success factors, and obstacles to the implementation of nexus solutions and investments. During the meeting, regional experiences of progress in applying nexus solutions and facilitating nexus dialogues were also presented and discussed. The regional overview encompassed Central Asia, South-East Europe and the Mediterranean as well as Middle East and North Africa. Afterwards, the main findings from the stocktaking exercise were discussed through individual interviews with experts and two regional consultations in Latin America and the Caribbean[49] and the Western Balkans.[50] The two consultations, involving experts and policymakers as well as regional and financial institutions with an interest and experience in cross-sectoral solutions and investments, provided a space for sharing lessons, proposals and reflections on ways forward for nexus activities in the two regions.

All the above-mentioned components of the second phase enriched the preliminary conclusions with further case studies, deepening some key aspects and clarifying regional trends (see sections 4, 5 and 6).

3.2 Emerging trends from the survey

As shown in section 2.3, the nexus approach is being applied to tackle a variety of problems and apply a variety of nexus solutions. It is possible, however, to highlight those problems that were more consistently tackled with a nexus approach in the survey as well as success factors that carried more "weight" when implementing solutions.

Common problems and root causes

Simply stated, the analysis suggested that – at least as far as the case studies were concerned – the problems addressed by nexus-oriented approaches were concerned more with environmental and qualitative issues than with quantitative issues (of water variability, for example). However, this does not imply that quantitative issues are not present, but rather that most of the solutions gathered tackle qualitative and environmental problems, indicating that quantitative issues are rarely tackled through a nexus approach. However, as discussed later, there are many examples where regional nexus dialogues focused specifically on the coordination of water infrastructure in order to tackle water quantity issues.

Regardless, there is remarkable agreement among the case studies about the highest-ranking root cause of problems tackled by nexus approaches around the world: anthropogenic hydrological change. The second-ranking root cause reported outside the European region is climate change.

Common typologies of solutions and underlying factors of success in implementation

According to the data, institutional solutions predominate over infrastructural approaches to a significant degree and, as far as infrastructure is concerned, green infrastructure is slightly more prevalent than built infrastructure. However, this type of approach may reflect the specific stakeholder constituency involved in the survey, which does not include, for example, energy companies, agribusinesses or industrial stakeholders.

The typologies of solutions and the underlying factors of success span a broad range. All the 26 factors of success (see Table 6) appeared in at least one case study. Two more factors of success were indicated in two of the case studies (marked as "other" in the table). A clear conclusion is that the wide-ranging suite of "institutional" factors of success predominate over the others; in other words, there is very limited mobilization of green infrastructure approaches (green) and even less of built infrastructure (grey). Accordingly, the most common factors of success in the cases analysed relate to the action of institutions and do not require the mobilization of resources for new infrastructural investments.

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[48] The presentations at and documentation for the meeting are available on the website of the Water Convention on the nexus webpage at: https://unece.org/environmental-policy/events/task-force-water-food-energy-ecosystems-nexus.

[49] Virtual meeting of experts on policies of the Water-Food-Energy-Ecosystems Nexus and projects of transboundary relevance in Latin America and the Caribbean (LAC). Online event organized by UNECE, ECLAC and IADB on 22 February 2021: www.water-energy-food.org//news/nexus-blog-virtual-meeting-of-experts-on-policies-of-the-water-food-energy-ecosystems-nexus-and-projects-of-transboundary-relevance-in-latin-america-and-the-caribbean-lac.

[50] Virtual meeting on Nexus Solutions and Investments in the Western Balkans. Online event organized by UNECE, GWP-Med and EIB on 5 May 2021: www.gwp.org/en/GWP-Mediterranean/WE-ACT/News-List-Page/2021/nexus-solutions-meeting.

Table 6. Success factors ranked from the most to the least common

Success factors	Type
1. Stronger transboundary cooperation	Institutional
2. Shared data and information	Institutional
3. Increased awareness of options for cross-sector transboundary trade-offs, compromise and synergies	Institutional
4. Innovative infrastructure operating rules	Institutional
5. Increased awareness of the benefits accruable to cross-sector transboundary trade-offs, compromise and synergies	Institutional
6. Institutional arrangements	Institutional
7. Renewable energy	Infrastructural (green)
8. Natural infrastructure	Infrastructural (green)
9. Standardized social and environmental impact assessments among sectors and between riparian states	Institutional
10. Legal arrangements	Institutional
11. Demand management policies	Institutional
12. Appropriate, well-enforced regulations	Institutional
13. Multipurpose use of existing infrastructure	Institutional
14. Innovative infrastructure	Infrastructural (grey)
15. Decentralized service delivery concepts	Institutional
16. Economically mobile water	Institutional
17. Functional, transparent incentive structure	Institutional
18. Small-scale conservation agriculture	Infrastructural (green)
19. Smart energy strategies	Institutional
20. New multipurpose basin-level infrastructure and/or related planning	Infrastructural (grey)
21. Large-scale conservation agribusiness	Infrastructural (green)
22. Innovative financing	Institutional
23. Common metrics	Institutional
24. Decentralized service infrastructure	Infrastructural (grey)
25. Transparent and equitable terms of transboundary trade between riparian states	Institutional
26. (Other) investment prioritization based on hydrological and other analyses	Institutional
27. Awareness-raising	Institutional
28. (Other) application and monitoring of measures to control erosion, creation of erosion maps	Institutional

Common trade-offs and synergies

While the survey could not provide clear insights into the trade-offs and synergies associated with nexus solutions, an analysis of success factors enables two conclusions to be tentatively drawn. First, at least five of the factors imply a trade-off related to water resource allocation (innovative infrastructure operating rules, demand management policies, multipurpose use of existing infrastructure, innovative infrastructure and new multipurpose basin-level infrastructure). Second, some of the institutional factors may involve other types of trade-offs in terms of political economy or geopolitics, potentially related to other resources such as energy, food and land (increased awareness of options for cross-sector, transboundary trade-offs, compromise and synergies; increased awareness of the benefits accruable to cross-sector transboundary trade-offs, compromise and synergies; and transparent and equitable terms of transboundary trade between the riparian states).

Constraints on implementation and enabling factors

The data set revealed a suite of eight constraints encountered by stakeholders when trying to implement nexus solutions: (i) politics; (ii) data and information shortcomings, (iii) inadequate institutions, (iv) financial constraints, (v) persistent policy/sector silos, (vi) limited technical capacity, (vii) limited time frames, and (viii) limited options for benefit-sharing.

Fortunately, the data also identified three possible ways in which such constraints could be, and in some cases were, obviated. These strategic enabling factors of nexus solutions in transboundary basins were: "well-focused programme-based support", "mainstreaming of national and sectoral plans into high-level development planning" and "common understanding and mutual trust". A further enabler that emerged during the sixth meeting of the Task Force on the Water-Food-Energy-Ecosystems Nexus, and at a recent virtual, global Workshop on Financing Transboundary Cooperation and Basin Development (16–17 December 2020) under the Water Convention,[51] was the involvement of high-level decision-makers and ministries of finance in transboundary (nexus) dialogues. Lack of involvement of high-level decision-makers is often a major obstacle that prevents riparian states from implementing concrete solutions (with or without a nexus approach). If transboundary dialogues lead to the identification of bankable projects, they can attract the attention of non-line ministries. Crucially, the cooperative nature of transboundary nexus dialogues has the potential to reduce political and financial risk for investors.

Perceived added value of nexus solutions

In this context, and due to the difficulty of drawing clear conclusions regarding trade-offs and synergies, the added value of nexus solutions corresponds to the benefits that they generate beyond the direct (sectoral) resolution of the problem in question, in qualitative terms. According to the survey (see Table 7), perceptions of added value were predominantly institutional in nature, trending through resource and regional security, with economic and financial added value coming last.

Table 7. Elements of added value of nexus solutions

Element	Percentage
Enhanced intersectoral cooperation (I)	65
Enhanced transboundary cooperation (I)	65
Better resilience or reduced risks (I)	58
Establishment of improved planning practices and paradigms (I)	52
Improved ecosystem services (R)	52
Greater transparency (I)	48
Improved infrastructural functionality (I)	42
Improved resource security (water, energy or food) (R)	42
Reduced tension (I)	42
Increased returns on investment (F)	30
Regional peace or stability (I)	28
Decentralized/devolved financing opportunities (F)	19
Increased returns on the factors of production (especially land and water) (R)	19
Reduced demands on line budgets (F)	16
Increased returns on sunk costs (F)	10

Note: I = Institutional, R = resource and regional security added value, F= economic and financial added value.

[51] Virtual workshop on financing transboundary water cooperation and basin development organized by UNECE: https://unece.org/environmental-policy/water/events/virtual-workshop-financing-transboundary-water-cooperation-and-basin.

The role of river basin organizations

Some regions lack the legal and/or institutional frameworks for transboundary cooperation among riparian states, notably river basin organizations (RBOs); and, even where these exist, their characteristics (e.g. organizational mandate, representation of riparian states, scope of the agreement) may affect their capacity to facilitate institutional cross-sectoral dialogues at transboundary level. How this affects opportunities for states to design and implement nexus solutions in these basins is a question the case study analysis was unable to answer due to lack of sufficient information. However, examples of RBOs supporting or participating in nexus solutions and investments are detailed in section 6.2, along with reflections on their actual or potential role.

Regional differences

The analysis of case studies gathered through the survey enabled an initial comparison of different global regions, in order to ascertain, for instance, whether the most common challenges in transboundary basins (and their root causes) vary from one to another. Due to the geographical distribution of cases, the sole meaningful comparison was between root causes reported in case studies from Europe (Western and Eastern) and those reported in case studies from other regions, as shown in Table 8. It should be noted, though, that the table only includes root causes that appear in at least 50 per cent of case studies, in order to compare those that are most commonly observed. While "anthropogenic change in hydrology" ranks highest both within and outside the European region, the other cited root causes differ. However, this does not mean that climate change did not emerge as a cause in case studies in the European region, or that inadequate finances were not cited outside the European region as well as other causes; see Table 8).

Table 8. Common root causes emerging from the survey

Most quoted root causes outside the European region (at least 50% of case studies)[52]	Most quoted root causes within the European region (at least 50% of case studies)
• Anthropogenic change in hydrology • Climate change • Data and information limitations • Poor land use and management • Poor intersectoral coordination • Poor water resource management	• Anthropogenic change in hydrology • Inadequate finances • Inadequate institutional capacity • Land use change

One surprising finding from the survey is that case studies from the Europe region cited "inadequate finances" as a challenge more consistently than case studies from other regions. This might suggest that cross-sectoral cooperation in the other regions is increasingly supported by development partners participating in the survey (even though support may be project-specific or limited to the basin region). However, it should be noted that perceptions of the availability of financial resources may vary greatly depending on the stakeholders (e.g. governmental or non-governmental actors), regardless of the region. Furthermore, the fact that the European region has the highest presence of framework agreements on transboundary waters may reflect the low level of endogenous root causes (poor resource management, data limitation, poor coordination) which are cited more consistently outside the European region.[53]

Sources of nexus investments and financing delivery pathways emerging from the survey

The topic of financing is rarely covered in the literature and responses to the survey included solutions that were not effectively implemented though dedicated investments. Hence, these aspects were initially reviewed based on the experience of the consultant carrying out the analysis of case studies.[54] The preliminary findings were discussed subsequently with experts as well as at regional consultations, as different regions rely on different sources of financing. In addition to globally active development banks, like the World Bank and the European Investment Bank, different regions have access to funding from regional or sub-regional institutions, such as the Asian Development Bank (ADB), the African Development Bank (AfDB), the Inter-American Development Bank (IADB), the European Bank

[52] "European region" here includes both Eastern and Western Europe.

[53] UNECE & UNESCO, Progress on Transboundary Water Cooperation: Global Baseline for SDG Indicator 6.5.2 (United Nations, Geneva, 2018).

[54] Phil Riddell, Taking Stock of Nexus Solutions and Investments in Transboundary Basins: a Synthesis (unpublished, 2020).

for Reconstruction and Development (EBRD), and so on. As lending to countries is typically provided by sector (e.g. WASH, agricultural development, energy and infrastructure), the sectoral breakdown and relative volumes of lending can vary;[55] hence, the issue of cross-sectoral coordination also concerns these institutions.

The fact that economic and financial types of added value ranked so low among respondents (mostly from the fields of water and the environment) may constitute an important barrier to establishing concrete dialogue between the water sector and other water-reliant sectors (e.g. energy, industry). In general, there seems to be little understanding of how the financing of nexus/multisectoral projects works in practice within water institutions. This represents a major capacity gap which prevents them from finding (or coordinating) bankable cross-sectoral projects. Moreover, given that valuing and pricing water in economic terms is much more problematic, for instance, than energy, the return on water investment may be either unclear or too low for potential investors. In many cases, water-reliant sectors find solutions to their water problems faster by themselves, thereby reinforcing silos.

The analysis of investments and financing focused on the overall data emerging from the survey (the literature review was effectively silent on the subject), and also took into consideration a data set provided by a complementary study on the financing of transboundary institutions.[56]

The types/sources of financing considered were:

- state funding (including credits from development partners)
- state funding with development partner grant support
- development partner grants (lending)
- blended finance, and
- private sector (and capital markets).

The financing delivery pathways considered were:

- project specific funding – funding for a single, discrete investment (infrastructural or institutional);
- specific programme financing (e.g. climate funds) – funding for a predetermined suite of investments (infrastructural and/or institutional);
- adaptable programme financing – funding for a suite of investments (infrastructural and/or institutional) that are not predetermined but have a common cascade of objectives and outputs;
- sector budget support – funding made available to line ministries or their decentralized/devolved authorities to be disbursed at their discretion; and
- central budget support – funding made available to non-line ministries and/or decentralized/devolved authorities to be disbursed at their discretion, or credit lines to national banks to support fast-tracked infrastructural projects.

Examination of the survey data available suggests that project-specific delivery pathways (financed by the state, with or without development partner support) are the most common. With minor exceptions, this trend appears even when the study data set is broken down by region, meaning that the trend applies almost equally to the entire world.

The analysis also included the search for a correlation between the financing delivery pathway and the type (and source) of investment. This is a pertinent question, particularly when it comes to consideration of infrastructural solutions and private sector financing, because programmatic funding is an efficient way to mobilize public finance and certain kinds of private financing (specifically bonds) for a series of infrastructural investments (especially if

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55 See for instance: Annalisa Prizzon and Lars Engen, *A Guide to Multilateral Development Banks* (Overseas Development Institute, London, 2018).

56 Phil Riddell, *Values of transboundary cooperation and management*. Report contributing to the IUCN study "Financing Transboundary Water Management" (unpublished, 2020).

basket funding modalities are possible),[57] thereby circumventing the hazards perceived in the public and private sectors with respect to financing water sector infrastructure.[58]

Within the limits of the data available, it is reasonable to say that a correlation exists between infrastructural measures and adaptable programmatic financing. Programmatic financing means that funds are allocated to a programme (e.g. modernization of irrigations systems in a river basin) without connection to a specific project. Funds can come from public or private entities, or both. While in principle such transboundary programmatic financing schemes are possible, they are not common.

One important limit of programmatic funding schemes is that they are typically designed by one sector and, in less-developed regions, with strict requirements from a donor. To be effectively "nexus", these schemes should be more adaptable and "smarter", implying that they should stimulate competition between eligible projects. In parallel, "basket funding" is typically associated with specific projects, although it may be more effective in support of programmes and, in general, at a higher level of politics where countries have more leverage to decide and more "space" across sectors.

In terms of private financing, the case studies highlighted an important gap, as responses revealed an overwhelming preponderance of state financing of one form or another. This observation may be biased by the fact that most of the survey responses came from public institutions and the fact that the solutions relate to water and environmental issues.

In fact, solutions in agriculture and energy (e.g. landscape agriculture, improved agribusiness, sustainable agricultural value chains, renewable energy or energy efficiency) constitute more likely entry points for private investments that could directly or indirectly tackle water and environmental issues. For example, large-scale agribusinesses are typically financed through private sector investments, and even though public funds may be allocated to cross-cutting research into sustainable agriculture, these might contribute indirectly to large-scale agribusiness development (e.g. through tax incentives, leases of public land and blended capital). Private-led solutions were not adequately represented in the set of case studies considered for the analysis.

Regarding relevance for non-line ministries and decision-makers (notably finance and economy), if nexus dialogues manage to align with multisectoral programmes (e.g. climate- or green economy-oriented programmes and, crucially, regional strategies), this may facilitate the necessary high-level support and related political decisions. Agreeable integrated packages of solutions, when supported by different sectors, are also more likely to convince finance ministries. This might represent an important step for water authorities in countries where water ranks low in national priorities for investment, and for water cooperation in basins where such cooperation needs to be stepped up.

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57 Basket funding indicates a mix of funds coming from different sources including public and private, national governments and international donors.

58 See for instance: OECD, Financing water Investing in sustainable growth, *OECD Environment Policy Papers* no. 11 (OECD, Paris, 2018).

4. REGIONAL NEXUS DIALOGUES

Since the nexus approach was first conceptualized in 2011,[59] several projects have aimed to generate regional cross-sectoral cooperation for sustainable development. Some of these dialogues have focused specifically on transboundary basins, such as the nexus assessments under the Water Convention and the dialogues organized within the framework of the BRIDGE project.[60] Other dialogues have targeted broader geographic scales, such as the Nexus Regional Dialogues Programme in the Middle East and North Africa (MENA), Latin America and the Caribbean (LAC), Central Asia, the Niger River Basin and Southern Africa,[61] but incorporated issues of management and cooperation in relation to shared water resources. These multi-country dialogues provide an important source of information on the application of the nexus approach in different regions.

The following six sections describe these dialogues in more detail, highlighting their relevance from the perspective of transboundary cooperation. The choice of regions while non-comprehensive reflects the centrality of this perspective in this study. It should be noted that the wide range of objectives of these different dialogue processes, and the different ways in which they were structured, makes comparison difficult. These dialogues do not adhere to a common methodology or even a common glossary, including an accepted definition of the term "nexus solution".

However, nexus dialogues always aim to achieve the same types of impact: facilitating sustainable development, enhancing policy coherence, improving efficiency of resource use, and supporting the design, evaluation and implementation of sustainable projects. They also share a focus on awareness raising and capacity building as a means to cope with nexus trade-offs and exploit nexus synergies. Furthermore, as the dialogues progressed over time they evolved from an initial focus on trade-offs towards a more solution-oriented approach.[62]

The following sections explore nexus dialogues approaches by region. The first two sections (South-East Europe and Latin America and the Caribbean) are based on regional expert consultations; the last four drawn on the literature and input from partners.

4.1. South-East Europe

South-East Europe extends from the Mediterranean to the Black Sea. This section focuses on the Western Balkans, which includes Albania, Bosnia and Herzegovina, North Macedonia, Kosovo,[63] Montenegro and Serbia. This area was also covered by the South-East Europe 2020 Strategy,[64] which incorporates environmental goals including the identification of steps and measures necessary for advancing the water, energy and food nexus approach at national and transboundary levels.

South-East Europe is a region with extensive forest coverage, where hydropower is a key energy source and many rivers are prone to flooding. The region includes several transboundary basins: the Tisza, Sava and Danube, which flow into the Black Sea; and the Krka, Drin, Aoos/Vijosa, Vardar/Axios and Struma/Stymonas, which flow into the Mediterranean. All the basins have associated aquifers.[65]

The region is characterized by several biodiversity hotspots and pristine natural areas, where conservation is sometimes threatened by infrastructural development, notably hydropower. The impact of climate change is felt

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59 Holger Hoff, Understanding the Nexus – Background Paper for the Bonn 2011 Conference: The Water, Energy and Food Security Nexus (Stockholm, Stockholm Environment Institute, 2011).

60 More information on the BRIDGE project is available on the IUCN website: www.iucn.org/theme/water/our-work/current-projects/bridge.

61 For more information on the Nexus Regional Dialogue Programme see: Factsheet: Nexus Regional Dialogues Programme Phase II, available at: www.water-energy-food.org/resources/fact-sheet-nexus-regional-dialogues-programme-phase-ii.

62 One of the goals of Phase II of the Nexus Regional Dialogue Programme is to "foster interest, awareness and engagement of investors for WEF NEXUS projects"

63 UN Security Council Resolution 1244.

64 Regional Cooperation Council, South East Europe 2020 Strategy (2013). Available at: www.rcc.int/pages/86/south-east-europe-2020-strategy.

65 GWP-Med, Draft Nexus Mapping Study in South East Europe, Background Study to support the Nexus Policy Dialogue Process in the SEE2020 Region. Available at: www.umweltbundesamt.de/en/topics/sustainability-strategies-international/cooperation-eeca-centraleastern-european-states/project-database-advisory-assistance-programme/water-food-energy-environment-nexus-policy-dialogue.

through decreased precipitation and rising temperatures, and the frequency of flood and drought episodes is increasing.[66]

The use of wood biomass for heating in households is widespread. Although this traditional practice is supported by large stock of forests, it nevertheless severely affects ecosystems through erosion and sedimentation, and in turn worsens water quality, alters hydromorphology and reduces water retention capacity. This has in some cases led to bans on logging practices. Sanitation coverage and wastewater treatment need improvement in many areas.

Recent advancements in cross-sectoral coordination have taken place mainly at the national level within institutional settings (albeit less concretely in policy integration). However, in the South-East Europe region several countries have embarked on nexus dialogues at the transboundary level, notably the Sava, Drina and Drin nexus assessments[67] carried out by UNECE (the last two are being implemented in partnership with the Global Water Partnership Mediterranean (GWP-Med) and are currently in their second phase).

In the case of the Drina River Basin, the transboundary dialogues were enriched by energy perspectives through dedicated energy-focused dialogues carried out at the national level with basin-focused discussions. These multi-stakeholder dialogues on renewable energy with a special focus on nexus opportunities[68] contributed to the development of a dedicated toolkit for renewable energy policymakers, to help them consider transboundary synergies and trade-offs early on in the energy planning process.[69] The process in the Drin and Drina River Basins is leading to the development of a nexus roadmap/strategy for the basin to (i) ensure the establishment of the necessary cross-sectoral coordination and institutional arrangements to support integrated policy and management for flow regulation, and (ii) facilitate the mobilization of actions and investments across sectors, notably for nexus priority projects.[70]

Transboundary nexus dialogues in the South-East Europe region have now reached the point where countries are starting to discuss solutions and investments (e.g. in the Drin and Drina).[71] These dialogues function as a forum for sharing experiences related to technical solutions already being implementing to optimize resource use (e.g. floating photovoltaic in reservoirs)[72] and discussing their transboundary implications and potential.

Crucially, countries in the region share sectoral as well as cross-cutting agendas (e.g. relating to water and the environment, energy transition, waste management, connectivity and mobility), which offers significant opportunities to leverage synergies across sectors at the regional level in order to better tackle region-wide issues. Because of the geographical and geopolitical proximity of the European Union (EU), these agendas align with EU strategies and standards. Two such examples are the Green Agenda for the Western Balkans (signed in Sofia in 2020[73] and implemented by the Regional Cooperation Council (RCC), as envisaged by the European Green Deal), and the EU Strategy for the Danube Region (EUSDR). The first of these emphasizes green growth, job creation and climate action through decarbonization of the energy system, waste management and sustainable food. The second has a basin-level scope and covers issues ranging from regional connectivity and mobility (in particular waterways), to sustainable energy, water quality, environmental protection and risks, biodiversity, institutional capacity and cooperation, security, competitiveness of enterprises, and knowledge and skills.

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66 UNECE, Reconciling Resource Uses in Transboundary Basins: Assessment of the Water-Food-Energy-Ecosystems Nexus in the Sava River Basin (United Nations, Geneva, 2015). Available at: https://unece.org/environment-policy/publications/reconciling-resource-uses-transboundary-basins-assessment-water-3.

67 All assessment reports are available on the website of UNECE at: https://unece.org/environment-policy/water/areas-work-convention/water-food-energy-ecosystem-nexus.

68 Dialogues carried out in Serbia and Bosnia and Herzegovina. More information on the ECE Renewable Energy Hard Talks is available at: https://unece.org/sustainable-energyrenewable-energy/unece-renewable-energy-hard-talks-unece-countries.

69 UNECE, Towards Sustainable Renewable Energy Investment and Deployment: Trade-offs and Opportunities with Water Resources and the Environment (UNECE, Geneva, 2020).

70 "Promoting the Sustainable Management of Natural Resources in South-eastern Europe, through the use of the Nexus approach" (2016-2021) is a project funded by the Austrian Development Agency (ADA), and implemented by GWP-Med and UNECE. Information on the project is available at: www.gwp.org/en/GWP-Mediterranean/WE-ACT/Programmes-per-theme/Water-Food-Energy-Nexus/seenexus.

71 The identification of nexus projects of transboundary value in the Drin and Drina is part of the project "Promoting the Sustainable Management of Natural Resources in Southeastern Europe, through the use of the Nexus approach" (UNECE and GWP-Med).

72 Energy Industry Review, "KESH's first floating solar photovoltaic plant in Albania" (2021): https://energyindustryreview.com/renewables/keshs-first-floating-solar-photovoltaic-plant-in-albania.

73 Sofia Declaration on the Green Agenda for the Western Balkans, 10 November 2020. Available at: www.rcc.int/docs/546/sofia-declaration-on-the-green-agenda-for-the-western-balkans-rn.

In this context, some regional cooperation initiatives and political processes clearly complement transboundary nexus dialogues – for instance, the "Task Force on the Nexus Approach" in the context of the Water Agenda of the Union for the Mediterranean (UfM), the GEF Nexus project for coastal zones under the UNEP/MAP Med Programme (Child Project 2.2: Managing the Water-Energy-Food and Ecosystems Nexus 2020-2024), and the Growth Strategy 2020 (Regional Nexus Policy Dialogue Process 2017-2019) led by the Regional Cooperation Council (RCC).

4.2 Latin America and the Caribbean

A significant proportion of the water resources in the Latin American region are shared. Of the 33 countries in Latin America and the Caribbean, 22 share transboundary rivers, lakes and aquifers. However, transboundary cooperation frameworks are largely lacking,[74] although exceptions exist in the Amazon and La Plata basins, the Sixaola river between Costa Rica and Panama, the Trifinio in Northern Central America and the Guaraní Aquifer.

A recent IUCN study on nexus trade-offs in the region[75] highlights the abundance of natural resources and acknowledges that economic development has produced important results; however, the study also found a high level of inequality and notes that segments of the population still lack access to water, energy and food. Environmental degradation brought about by pollution and deforestation is compromising globally important ecosystems, such as rainforests, while climate change exerts pressure through changing rainfalls patterns and increased frequency of extreme events. As a result, some regions that are naturally water rich have recently experienced water insecurity.

The study also highlights the following strategic priorities for nexus approaches in the region: coherent landscape planning (beyond single projects), strengthening water governance (reducing fragmentation and improving coordination of actors), enhancing monitoring systems (reducing pollution and improving efficiency of use), quantifying trade-offs (evaluation of future scenarios for informed decision-making), decoupling agriculture from deforestation and adjusting price signals in water and agriculture (including payment for ecosystem services).

[74] UNECE & UNESCO, *Progress on Transboundary Water Cooperation: Global Baseline for SDG Indicator 6.5.2* (2018).

[75] Helen Bellfield, *Water, Energy and Food Security Nexus in Latin America and the Caribbean*, Global Canopy Programme, 2015. Available at: https://portals.iucn.org/library/sites/library/files/documents/2015-022.pdf.

A consultation with experts from the region[76] highlighted the fact that the application of the nexus approach to policy-making and transboundary contexts is hampered by a lack of convincing examples where the approach added value. However, several countries have experience of improving nexus coordination at country level, thereby generating opportunities to advance the nexus approach in the region.[77] In Bolivia, for instance, the National Irrigation Development Plan and Agenda 2025 prioritized more efficient use of water and land in their design of irrigation infrastructure.[78] Meanwhile, in Chile the Irrigation Law established the use of renewable energies in irrigation systems.[79] Other examples of shared infrastructure are presented in the next chapter (see section 5.1).

There is increasing acceptance among countries in the region that ecosystems should be better protected and appropriately valued in development plans, including in transboundary basins. Cross-sectoral and transboundary coordination and the promotion of nature-based solutions all form part of a paradigm shift from traditional integrated water resource management (IWRM) to water security in some countries that consider the concept of water security in their plans (e.g. Argentina, Brazil, Panama and Peru). This approach is supported by the strategies of donors and financing institutions (see section 6.1, Latin America case study), like that of the IADB, which is working to pilot this innovative approach in countries such as Chile, including at the transboundary level and through investment solutions.[80]

4.3 Middle East and North Africa

The Middle East and North Africa (MENA) region is one the most water scarce in the world. Some 18 out of 22 Arab countries are below the renewable water resources scarcity annual threshold of 1 000 m^3 per capita, and 13 are below the absolute water scarcity threshold of 500 m^3 per capita per year.[81] Desalinization of seawater and highly mineralized groundwater is employed extensively in the region. Several states in the region have resorted to the reuse of treated wastewater to fill the gap between conventional water resources supply and demand. Nearly half of the collected wastewater that is safely treated is reused in the region, and approximately one-quarter is used for irrigation and groundwater recharge. The Gulf Cooperation Council Member States use 90 to 100 per cent of their safely treated wastewater.[82] The main concern surrounding wastewater treatment and reuse has been the associated cost and the high energy demand, although the latter may be offset by energy efficiency measures during design and operation. Renewable energy may also be used to offset the energy demand of wastewater treatment, and recovered biogas can be used for the generation of heat and electricity. Involvement of the private sector can help alleviate initial capital costs.

Food security is deeply linked to the management of scarce water resources, which has in many cases led countries to prioritize food self-sufficiency in order to reduce vulnerability to imports and price volatility.[83]

Experience of implementing nexus solutions in transboundary contexts is limited and transboundary cooperation frameworks are largely lacking;[84] however, some countries are highly committed to improving strategic resource efficiency, notably in regard to water (e.g. the FAO project "Water efficiency, productivity and sustainability in the

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76 Virtual event organized by UNECE in cooperation with the United Nations Economic Commission for Latin America and the Caribbean (ECLAC) and the Inter-American Development Bank (IADB) on 22 February 2021. More information at: www.water-energy-food.org//news/nexus-blog-virtual-meeting-of-experts-on-policies-of-the-water-food-energy-ecosystems-nexus-and-projects-of-transboundary-relevance-in-latin-america-and-the-caribbean-lac.

77 ECLAC notably has supported national level work on the nexus, including in cooperation with GIZ. This support includes the development of national-level guidance: Lisbeth Naranjo and Barbara A. Willaarts, "Guía metodológica: diseño de acciones con enfoque del Nexo entre agua, energía y alimentación para países de América Latina y el Caribe", serie *Recursos Naturales y Desarrollo*, No. 197 LC/TS.2020/117 (Santiago, Comisión Económica para América Latina y el Caribe (CEPAL), 2020); Barbara A. Willaarts and others, "Análisis comparativo de acciones con enfoque del Nexo Agua-Energía-Alimentación: lecciones aprendidas para los países de América Latina y el Caribe", serie *Recursos Naturales y Desarrollo*, No. 204 (LC/TS.2021/18) (Santiago, Comisión Económica para América Latina y el Caribe (CEPAL), 2021) (in Spanish).

78 Alba Llavona, "Lecciones del Estado Plurinacional de Bolivia para la adopción del enfoque del Nexo: análisis del Plan Nacional de Cuencas, el Sistema Múltiple Misicuni y las políticas de riego", serie Recursos Naturales y Desarrollo, No. 203 (LC/TS.2020/168) (Santiago, Comisión Económica para América Latina y el Caribe (CEPAL), 2020) (in Spanish).

79 Elisa Blanco, "Lecciones de Chile para la adopción del enfoque del Nexo: análisis de políticas de fomento de tecnologías de riego, gestión integrada de cuencas, fondos de agua y energía sostenible", serie *Recursos Naturales y Desarrollo*, No. 202 (LC/TS.2020/164) (Santiago, Comisión Económica para América Latina y el Caribe (CEPAL), 2020) (in Spanish).

80 IADB, Agua para el futura: Estrategia de seguridad hídrica para America Latina y el Caribe (IADB, Washington, DC, 2020) (in Spanish).

81 FAO, AQUASTAT database. Available at www.fao.org/nr/water/aquastat/data/query/index.html?lang=en.

82 ESCWA, *Wastewater: An Arab Perspective* (ESCWA, Beirut, 2017).

83 FAO, *Does Improved Irrigation Technology Save Water? A Review of the Evidence,* Discussion paper on irrigation and sustainable water resources management in the Near East and North Africa (FAO, Cairo, 2017).

84 UNECE & UNESCO, *Progress on Transboundary Water Cooperation: Global Baseline for SDG Indicator 6.5.2* (United Nations, Geneva, 2018).

Near East and North Africa regions (WEPS-NENA)").[85] The region also has significant solar potential with promising, innovative solutions in the area of water and energy (e.g. solar-powered desalination). Beyond technical solutions, opportunities exist to apply the same logic of resource use optimization at the regional level, indirectly improving the management of scarce resources (see section 5.3, EcoPeace Middle East case study). Also of note is the experience of the North West Saharan Aquifer System,[86] where a transboundary nexus assessment led to the joint identification of a "package of solutions" that considers trade-offs, synergies and past experiences of implementing similar solutions in the countries concerned (see section 6.2, NWSAS case study).

4.4 Central Asia

In Central Asia, water, energy and land resources are highly interrelated due to the natural geography of the region. Formerly part of the Soviet Union, the countries of Central Asia are now independent but remain strongly inter-dependent as most of their water comes from the same source. Two main large transboundary rivers (the Amu Darya and the Syr Darya) cross the region and discharge into water bodies that represent the remains of the former Aral Sea, a once thriving salty lake that has now largely dried up due to the exploitation of water resources. In this context, upstream-downstream cooperation is vital to ensure water and food security as well as energy security.

The transboundary dimension of the water-energy-food ecosystems nexus is therefore paramount in Central Asia, a prominence reflected in the nexus dialogue facilitated by the Regional Environmental Centre for Central Asia (CAREC) and IUCN, which focused largely on water infrastructure, and the nexus assessment in the Syr Darya, which identified the main intersectoral issues and solutions in this river basin. Prospects exist to optimize resource use at the regional level though trade agreements (e.g. on food and energy), while drawing on past experiences in the region itself. In particular, Kazakhstan is promoting an initiative to create an International Water and Energy Consortium, a sustainable regional mechanism for the use of water and energy resources that considers the economic interests of all stakeholders and corresponds to current economic realities.[87] However, while the region has a long history of transboundary nexus cooperation, current schemes are in need of re-evaluation and in some cases are being reviewed.

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85 The project is implemented in Algeria, Egypt, Jordan, Iran, Lebanon, Morocco, Tunisia and the State of Palestine.

86 UNECE, Reconciling Resource Uses: Assessment of the Water-Food-Energy-Ecosystems Nexus in the North Western Sahara Aquifer System, Part A – "Nexus Challenges and Solutions" (UNECE, Geneva, 2020).

87 *The Astana Times*, "Central Asian leaders hold first Aral Sea summit since 2009, agree to develop action plan" (2018). Available at: https://astanatimes.com/2018/08/central-asian-leaders-hold-first-aral-sea-summit-since-2009-agree-to-develop-action-plan.

Under the United Nations Special Programme for the Economies of Central Asia (SPECA), member countries agreed that the Working Group on Water, Energy and the Environment would provide a platform for supporting progress on strategic issues related to water, energy and the environment, with a view to achieving the respective SDGs – taking into account interlinkages between these sectors. The Working Group also intends to promote consideration of energy and water cooperation opportunities, including inter-sectoral and transboundary cooperation; act as a platform for the identification, development and coordination of technical programmes and projects; and identify countries' priorities and emerging issues and consult on regional and collaborative approaches to address them. In the "Concept for a SPECA Strategy on Water, Energy and Environment" (2019), the Working Group recommended that the following areas be prioritized:

- identification of economic, investment and policy development opportunities in the water-food-energy-ecosystem nexus to coherently achieve targets under SDGs 6 and 7 (e.g. through the application of renewable energy technologies, agro-sector resilience measures, etc.);
- capacity building for the sustainable management of natural resources (the water, energy and agro/forestry sectors) at national and regional level;
- a feasibility study for a water-energy consortium; and
- improvement in information supply and exchange of experience on inter-sectoral solutions.

According to experience from the Central Asia Nexus Regional Dialogue Programme (implemented by CAREC in cooperation with IUCN during the first phase), there is a high level of awareness of nexus issues, but the design and operationalization of nexus solutions remains slow, hampered mainly by capacity and financing gaps.[88] For this reason, the programme has shifted from trade-offs to solutions and also to investments (making the case for nexus cooperation as a means to increase returns on investments).[89] The following programme outputs are therefore considered the core elements of its second phase:

[88] CAREC, Presentation at the sixth meeting of the Task Force on the Water-Food-Energy-Ecosystems Nexus under the Water Convention (22–23 October 2020).

[89] IUCN & CAREC, Increasing Returns on Investment Opportunities by Applying a Nexus Approach: Best Practice Nexus Case Studies (IUCN, Belgrade, 2019).

- the Nexus Investment Portfolio, which includes eight project ideas of regional importance and covers a wide range of transboundary natural resources management issues, including water allocation, dam safety, upgrading of technical systems, eco-tourism, combating desertification and other environmental issues of the Aral Sea confirmed relevant by all project countries; and
- proposals for nexus investments in two transboundary water facilities, the Farkhad Dam and reservoir in Tajikistan and the Tuyamuyun hydroelectric complex bordering Uzbekistan and Turkmenistan (the latter is a demonstration project for which a Technical Working Group has been formed).

4.5 South-East Asia

South-East Asia is home to major transboundary river systems such as the Mekong, the Red River and the Salween. The river systems are being developed at a rapid rate to promote economic growth in the region. Different sectors such as hydropower, irrigation, fisheries and navigation face challenges due to variable or regulated hydrological regimes, floods, drought, rapid development, land use change and climate change. Ensuring that planned development guarantees long-term ecological and economic sustainability will require integrated approaches that look beyond national borders and consider the watershed dimension of planning.

The transboundary dimension of the above developments is important. In 2010, a strategic environment impact assessment prepared for the Mekong River Commission was published outlining the benefits, costs and risks of the planned construction of 88 new hydropower dams in the Lower Mekong Basin by 2030.[90] While the proposed developments would increase hydroelectric power generation nine-fold, it would diminish wild fish catch by 24–40 per cent.[91] Wild fish represent a significant source of protein and micronutrients for the 60 million people living in the Lower Mekong Basin, so the decrease in fish supply would require the development of alternative sources of protein through trade or local production.[92] In these complex systems, where trade-offs exist between water, food and energy, in areas such as the production of alternative crops, cross-sectoral decisions that consider different variables are of increasing importance. The Mekong River Commission, for example, has emphasized the

[90] International Centre for Environment Management (ICEM), MRC Strategic Environmental Assessment (SEA) of Hydropower on the Mekong Mainstream: Summary of the Final Report (ICEM, Hanoi, 2010).

[91] Jamie Pittock and others, "Modeling the hydropower–food nexus in large river basins: A Mekong case study" (*Water*, 2016) vol. 8, no. 425.

[92] Jamie Pittock and others, "The Mekong River: trading off hydropower, fish and food" (*Reg Environ Change*, 2017) vol. 17, pp. 2443–2453.

importance of a nexus approach in the context of a changing climate for improved cooperation for water, energy and food security (see section 6.2).[93]

Nexus projects and dialogues in the region (with actual or potential transboundary relevance) include an assessment of nexus trade-offs in the 3S River Basins (see section 5.3) and a study in Myanmar on sustainable hydropower and multipurpose storage (green and grey water) to meet the water, food and energy SDGs.[94]

4.6 Sub-Saharan Africa

Africa is home to most of the world's major transboundary watercourses – the Congo, Incomati, Limpopo, Niger, Nile, Okavango, Orange, Senegal, Volta and Zambesi – which together account for some 90 per cent of the continent's surface water resources. Various shared river basins in the region and a few aquifers are covered by bilateral or multi-lateral agreements.[95]

Sub-Saharan Africa[96] is the region with the highest level of food insecurity in the world, affecting almost 30 per cent of the population.[97] According to World Bank calculations, only half of the total population has access to electricity,[98] while hundreds of million people in the region lack safe water services (only 27 per cent and 18 per cent have access to drinking water and sanitation, respectively).[99] Accordingly, water sector development is central to the socio-economic development of the region.

Issues of natural resource insecurity are exacerbated by climate change, drought and land degradation. These issues can lead to competition and conflict between different user groups. For instance, the Sahel region has experienced a deterioration in its security situation over the last decade with a rise in armed conflict, rebel groups and terrorism. Future infrastructure development must therefore tackle food security, renewable energy generation and clean water supply, while also taking into account future climate trends, all with a basin-level approach to planning to enhance resilience[100] and, in turn, peace. Where infrastructure is under-developed there are also opportunities to "leapfrog" the problems brought about by development in other regions, by using the latest technology and new planning approaches, including the nexus approach.

The nexus trade-offs at stake in the development of water infrastructure in sub-Saharan Africa were the focus of a research study by IUCN, the Infrastructure Consortium for Africa (ICA) and the International Water Association (IWA). As water is a cross-cutting resource for development, water sector infrastructure provides the best opportunities for multi-functionality. The study indicated that the nexus approach is not commonly applied or operationalized, and that more coordinated efforts are required by stakeholders at all levels. A need was also identified to move away from siloed thinking within regional and national authorities, as well as development partners, and to accept that there is no "one-size-fits-all" nexus solution to water issues.[101]

Water is also key for energy development in sub-Saharan Africa. Almost 100 per cent of electricity production in many countries of the region (e.g. Democratic Republic of Congo, Lesotho, Malawi and Zambia) is generated by means of hydropower. The continent is divided into five regional "power pools" that allow countries to export and import electric power from each other to meet local demand. Regional and transboundary cooperation can help countries share the benefits of investments by optimizing the use of resources at the regional level. Where the availability of resources within the region is not evenly distributed cooperation means shared benefits. This is the case, for instance, of the multipurpose Kandaji dam on the Niger River, the benefits of which are shared by Nigeria and the Republic of Niger.[102]

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93 Hanne Bach and others, Cooperation for Water, Energy and Food Security in Transboundary Basins under Changing Climate (Mekong River Commission, Lao PDR, 2014).

94 More information about this study by IHE-Delft can be found at: www.un-ihe.org/projects/sustainable-hydropower-and-multipurpose-storage-meet-water-food-and-energy-sdgs.

95 Progress on Transboundary Water Cooperation: Global Baseline for SDG Indicator 6.5.2 (United Nations, Geneva, 2018).

96 The whole African continent excluding the North African countries: Algeria, Egypt, Libya, Morocco and Tunisia.

97 UN-Water, SDG 6 Synthesis Report 2018 on Water and Sanitation (United Nations, Geneva, 2018).

98 World Bank database.

99 Ibid.

100 Raffaello Cervigni and others, Enhancing the Climate Resilience of Africa's Infrastructure: The Power and Water Sectors. Overview booklet (World Bank, Washington, DC, 2015).

101 IWA/IUCN/ICA, Nexus Trade-Offs and Strategies for Addressing the Water, Energy and Food Security Nexus in Africa (Geneva, 2016).

102 Alfonso Medinilla, *Understanding the Niger Basin Authority (NBA/ABN) Reconciling upstream and downstream interests on the Niger River*, ECPDM Policy Brief (ECPDM, Maastricht, Netherlands, 2017). Available at: https://ecdpm.org/wp-content/uploads/NBA-Background-Paper-PEDRO-Political-Economy-Dynamics-Regional-Organisations-Africa-ECDPM-2017.pdf.

An examination of the Southern Africa Development Community (SADC) region – the focus of the Nexus Regional Dialogue Programme implemented by SADC and GWP-Southern Africa – shows that 85 per cent of the region's water resources are transboundary in nature.[103] SADC coordinates transboundary water cooperation in 15 basins across Southern Africa.[104] These shared basins present opportunities for cooperation to enhance socio-economic security and ensure further progress towards achieving the SDGs. The Regional Dialogue Programme (2017-2019) resulted in the development of a "Water Energy Food (WEF) Regional Governance Framework" to strengthen WEF Nexus governance in the region and to attract high-level political buy-in and interest. The framework was validated by SADC member states and approved by ministers of water and energy in 2020. The programme will also deliver a web-based regional investment project screening and appraisal tool to help make decisions on nexus investments. The Nexus Dialogue Programme implemented by the Niger Basin Authority (NBA) and the GIZ achieved a similar result by integrating the Nexus approach into the operational planning of the NBA, which covers 350 projects.

Another example of transboundary cooperation for climate resilient water infrastructure planning (green and grey) is the Volta River Basin, shared between Benin, Burkina Faso, Côte d'Ivoire, Ghana, Mali and Togo. The project "Water Infrastructure Solutions from Ecosystem Services" (WISE-UP) fosters cooperation on this issue to achieve poverty reduction, ecosystem management, growth and climate resilience while assessing trade-offs across sectors in the basin. Critical water resource challenges can be addressed through improved mechanisms for coordination among riparian states, increased water storage for subsistence farmers, reduction in waterborne diseases, support for biodiversity, and efforts to derive maximum benefits from hydropower through existing and planned hydropower plants.[105]

A final example of applying a nexus lens to transboundary water governance is provided by the project "Support to the integrated management of water resources of the Lake Kivu and Ruzizi River Basin", which encompasses Burundi, the Democratic Republic of Congo and Rwanda. Lake Kivu and the Ruzizi River have been subjected to the impacts of increasing agricultural and hydropower development, as well as natural gas extraction (from the lake), and face significant challenges related to water quality, among others. The project, implemented by GIZ and co-financed by the European Union and the Government of Germany, seeks to increase the capacity of the transitory trilateral basin organization ABAKIR (Lake Kivu and Ruzizi River Basin Authority) to become a lead mechanism in the institutionalization of a water-food-energy nexus-based approach to transboundary water management, an approach that is multi-sectoral, multi-stakeholder and takes place at multiple scales.

[103] Mabhaudhi and others, "Southern Africa's water–energy nexus: towards regional integration and development" (*Water*, 2016), vol. 8, no. 6, p. 235.

[104] UN-Water, *Water Security and the Global Water Agenda* (United Nations, Geneva, 2013).

[105] IUCN, "WISE-UP to climate: water infrastructure solutions from ecosystem services underpinning climate resilient policies and programmes", leaflet of the project (n.d.). Available at: www.iucn.org/sites/dev/files/content/documents/wise_up_brochure_en.pdf.

5. SELECTED EXAMPLES OF NEXUS SOLUTIONS AND INVESTMENTS

This section provides examples of nexus solutions and investments that have been implemented (or at least designed) through a nexus approach and are designed to bring about clear transboundary benefits. The examples are presented by typology of solution, highlighting key success factors that supported implementation (see section 2.2). The aim is to illustrate the variety of possible solutions and investments.

5.1 International cooperation

This section presents two case studies. The first focuses on the Paraná River Basin and illustrates the benefits that can be generated by applying a coordinated and cross-sectoral approach to the management of shared infrastructure, taking into account the surrounding territory, its ecosystems and variety of stakeholders. The second highlights the potential benefits of future energy policy actions related to renewable energy and energy efficiency on the use of shared water resources in the Syr Darya River Basin.

The Paraná River: Multi-purpose shared infrastructure

Riparian countries: *Brazil and Paraguay*

Sectors: *water, agriculture, energy, industry*

Transboundary problems tackled: *water quantity, water quality, environmental issues*

Success factors in focus: *multi-purpose use of existing infrastructure*

Financing source: *Itaipu Binacional (binational entity)*

Financing delivery pathways: *project-specific funding, specific programme financing (e.g. climate funds), adaptable programme financing*

Transboundary cooperation framework and/or project: *Treaty of Itaipu 1973 (legal instrument for the exploitation of the hydroelectric potential of the Paraná River)*

Itaipu Binacional is a binational entity created in 1974 by the Governments of Paraguay and Brazil to utilize the water from the shared Paraná River to generate hydropower. The hydropower plant – the world's second largest by installed capacity (14 000 MW), and the largest in terms of accumulated production (more than 2.7 billion MWh) – is located in the Paraná River on the border between the two countries.

Hydropower production requires secure, high-quality (low sediment), continuous water flow to maintain generation and supply for both countries. Moreover, the reservoir is used not only for electricity generation but also for agriculture, fishing, aquaculture, touristic and leisure purposes, as a municipal water source, and for maintaining wildlife and ecosystem services. Ongoing modernization efforts aim to improve energy and water use efficiency.[106]

Itaipu leads a range of activities to conserve and maintain the quality and conditions of these water-related ecosystems: "*In relation to terrestrial ecosystems, about 101 000 hectares of forests surround the Itaipu reservoir. This area represents the protected belt for the reservoir along the Brazilian and Paraguayan margins. Itaipu manages within this area a total of 10 protected areas including biological sanctuaries and reserves that protect native flora and fauna and advance research and conservation initiatives. These areas and the reservoir provide valuable connections among important remnants of the Atlantic Forest located in Paraguay, Brazil and Argentina*".[107]

As agriculture (mainly soy, corn, poultry, swine and milk production) is the main economic activity in the region, agricultural activities must be well managed to avoid soil erosion and river basin sedimentation and to reduce pollution.

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[106] Generating Hydropower through Sustainable Management of Natural Resources. Sustainable Water & Energy Solutions Network. Available at: www.un.org/en/waterenergynetwork.

[107] Ibid.

To manage these risks, Itaipu takes a watershed approach to the restoration of ecosystems by investing in forest restoration, biodiversity conservation, the management of protected areas, the recovery and protection of springs, and practices for water and soil conservation (including activities to mitigate the impacts of agrochemicals from rural areas).

The implementation of an integrated approach to resource management is not trivial, as stakeholders in municipalities and other institutions tend to maintain a sectoral perspective on common issues. Hence, Itaipu's activities in the field of environmental protection are carried out with the active participation of communities near the reservoir and water basins, and through the creation of partnerships with various stakeholders (municipalities, farmers and farmer organizations including associations and cooperatives, schools and universities, NGOs, and federal, state and municipal research and technical support institutions).

Itaipu receives permanent funding for specific areas including water quality monitoring, carbon emissions and sequestration, and forest restoration. Education for sustainability and capacity-building are implemented as strategic transversal activities and developed in partnership with other national and international institutions and/or governments.

Syr Darya: Renewables and energy efficiency to reduce pressure on shared waters

Riparian countries: *Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan*

Sectors: *water, energy*

Transboundary problems tackled: *water quantity*

Success factors in focus: *Increased awareness of the benefits accruable to cross-sector transboundary trade-offs, compromises and synergies*

Financing source: *N/A*

Financing delivery pathways: *N/A*

Transboundary cooperation framework and/or project: *Agreement between the Republic of Kazakhstan, the Kyrgyz Republic, the Republic of Tajikistan, Turkmenistan and the Republic of Uzbekistan on Cooperation in the Field of Joint Management on Utilization and Protection of Water Resources from Interstate Sources (1992); the International Fund for Saving the Aral Sea*

The Syr Darya's water resources are central to hydropower generation in upstream countries (Kyrgyzstan and Tajikistan) as well as agricultural production in densely populated parts of the basin downstream (Kazakhstan and Uzbekistan). There is a clear trade-off as demand in upstream countries for energy, especially electric power, peaks during winter, while irrigated agriculture requires water during the summer. These demands and dependencies could be reduced.

The Syr Darya nexus assessment carried out under the Water Convention presented a proposal, backed by water-energy modelling, for investing in renewable energy and energy efficiency as a solution to reduce stress on shared water resources.[108]

The assessment helped to determine measures and actions to optimize the use of these resources and identify benefits of transboundary intersectoral cooperation. In the energy sector, these measures included increased diversification of energy sources, improved functioning of the regional power system, revitalization of the power trade and improved energy efficiency. In the field of agricultural water use, they included furthering the ongoing transformation of agriculture with a focus on improved efficiency of water use, crop switching and land reform, among others.

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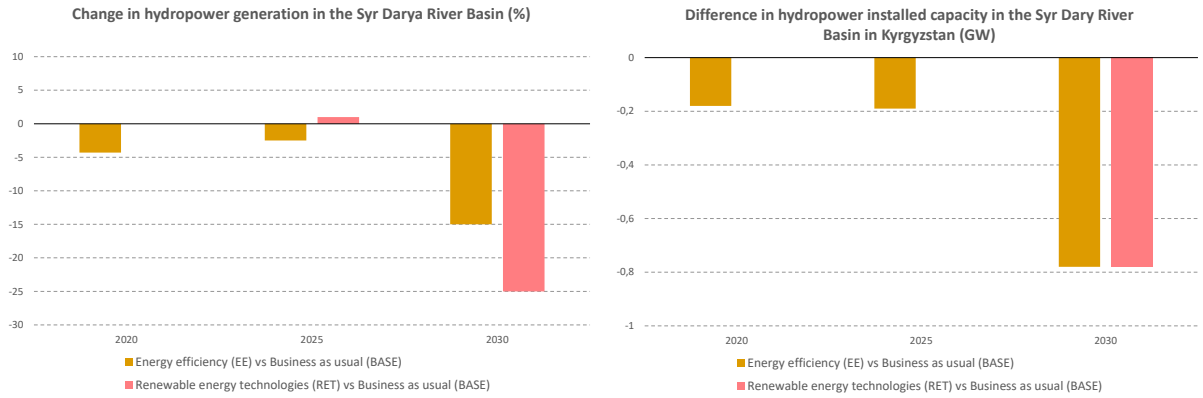
[108] The assessment aimed to foster transboundary cooperation by identifying intersectoral synergies and determining measures that could alleviate tensions related to the multiple needs of the riparian states for common resources. The participatory assessment process for the Syr Darya involved an intersectoral workshop for identification of the main intersectoral issues and possible solutions, detailed by a subsequent analysis, and followed by consultations of the various sectoral authorities concerned. See: UNECE, *Reconciling Resource Uses in Transboundary Basins: Assessment of the Water-Food-Energy-Ecosystems Nexus in the Syr Darya River Basin* (UNECE, Geneva, 2017).

A multi-region model of the electricity systems of riparian states was developed to investigate dependencies between Syr Darya water resources and the power systems sector. This system allows for the simulation of causes and effects from changes in upstream hydropower generation. In order to identify opportunities for cooperation, scenarios were developed for the operation of integrated power systems of Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan, and the dynamic responses of electricity trading and changes in electricity generation profiles were then analysed.

Among many "potential futures", the analysis focused on three scenarios. The reference scenario represented business-as-usual conditions (BAU scenario). A second scenario was dedicated to exploring the potential benefits of stated efforts to implement energy efficiency measures, targeting both supply and demand sides (EE scenario), and applying measures identified in the Power Sector Development Regional Master Plan.[109] A third scenario investigated the impacts of diversifying the power generation mix via the increased deployment of renewable energy technologies (RET scenario), such as wind power and solar photovoltaic power. Electricity trading was analysed across the three scenarios in order to assess how different conditions impact the dynamics of power flows in the region and the generation mix of the countries. Of particular interest were the implications for hydropower generation patterns in the upstream countries of Kyrgyzstan and Tajikistan (Figure 2).

There is a significant need for investments to modernize existing infrastructure in order to ensure higher efficiency of use of basin resources and secure their protection. Relevant courses of action identified by the assessment include further development of the regional energy market and electricity trading, as well as the exploration of opportunities for energy-water exchanges on the basis of coordinated strategic planning for the development of electric power systems and water use. Greater involvement on the part of the energy sector within basin-wide frameworks of institutional cooperation would create more options to pursue nexus opportunities.

Figure 2: Possible reduction in hydropower dependency in the Syr Darya River Basin



Note: The left-hand graph shows the change in hydropower generation in the Syr Darya River Basin (%). The right-hand graph presents the difference in hydropower installed capacity in the Syr Dary River Basin in Kyrgyzstan (GW). Both graphs compare a business-as-usual scenario with energy efficiency (EE) and renewable energy technologies (RET) scenarios.

Source: UNECE, Reconciling Resource Uses in Transboundary Basins: Assessment of the Water-Food-Energy-Ecosystems Nexus in the Syr Darya River Basin (UNECE, Geneva, 2017).

[109] Fichtner GmbH & Co. KG, *Central Asia Regional Economic Cooperation: Power Sector Regional Master Plan*, Technical assistance consultant's report for the Asian Development Bank, (Manila, ADB, 2012).

5.2 Governance

This section presents a case study from the Isonzo/Soča River Basin related to data and information sharing and common metrics to coordinate decisions on multiple sectoral uses based on water suitability.

Isonzo/Soča River Basin: Coordinated and aligned decisions in hydropower, fishery, fishing and bathing based on the suitability of water courses and riparian areas

Riparian countries: *Italy and Slovenia*

Sectors: *water, food, energy, environment, tourism*

Transboundary problems tackled: *water quantity, environment*

Success factors in focus: *Shared data and information, common metrics (standardized river corridor suitability analyses)*

Financing source: *European Regional Development Fund and national funds*

Financing delivery pathways:*: project specific*

Transboundary cooperation framework and/or project: *Coordinated Activities for Management of Isonzo–Soča (CAMIS) project*

The Institute for Water of the Republic of Slovenia has developed a method for determining the suitability of water courses and riparian areas for various water uses and intersectoral coordination, based on knowledge of (i) water and spatial planning; (ii) spatial, landscape and ecological as well as hydrological and hydraulic modelling; (iii) hydromorphological assessments; and (ii) administrative procedures, sectoral interests and cross-sectoral solutions. The method is used to develop sustainable solutions for the use of water courses and their riparian areas (i.e. river corridors).[110]

Under the Coordinated Activities for Management of Isonzo–Soča (CAMIS) project, co-funded by the European Regional Development Fund and national funds, this method was applied to the upper part of the Soča river basin in Slovenia to four types of use in the area: hydropower, bathing sites, fish farming and fishing. This universal method can be applied to any form of water use and implemented in any river, river basin or catchment area. The CAMIS project involved partners from both riparian countries.

Active stakeholder involvement in the development of solutions constitutes an integral part of the entire process. Such participation is crucial and encompasses the gathering and recording of data on environmental status, data analyses and model development, the coordination of decision-making and the proposal of solutions. Taking stakeholder competencies, expertise and interests into account contributes significantly to overall efficiency, enhances overall understanding of (and support for) decisions, and supports the implementation of solutions.

5.3 Economic and policy instruments

This section presents four case studies. The first focuses on the Sekong, Sesan and Srepok 3S river basins and illustrates national-level policy actions and legal arrangements in the field of energy, originating from a nexus assessment (and other multi-sectoral studies) at the basin level, which highlighted the benefits of cross-sector transboundary cooperation. The second case study examines a proposal which explores how international cooperation around the water-energy nexus could help optimize the use of scarce resources and bring economic benefits to a region where major water and energy decisions are commonly political in nature. As national-level intersectoral coordination is a pre-condition for finding and implementing transboundary nexus solutions, the section also includes a case study on the Alazani/Ganykh River Basin examining how national sectoral and cross-sectoral planning have been influenced by the outcomes of a transboundary nexus project, and another case study on the Dniester River which looks at advances in legal arrangements that take into account environmental needs in the context of dam operations.

[110] CAMIS Project brochure. Available at: www.camisproject.eu/modules/uploader/uploads/system_menu/files_sys/camis_zlozenka-izvrs_angl_low.pdf.

The Sekong, Sesan and Srepok 3S river basin: Optimizing water usage through transboundary cooperation[111]

Riparian countries: *Cambodia, Lao PDR and Viet Nam*

Sectors: *water, energy, agriculture, fisheries.*

Transboundary problems tackled: *environment*

Success factors in focus: *increased awareness of the benefits accruable to cross-sector transboundary trade-offs, compromise and synergies*

Financing sources: *the state with development partner grant support*

Financing delivery pathways: *sector budget support; project specific funding*

Transboundary cooperation framework and/or project: *Regional Technical Advisory Group*

The transboundary Sekong, Sesan and Srepok (3S) river basin covers 10 per cent of the Mekong basin, and provides 20 per cent of its water and sediment. The 3S basin is rich in land, forest and hydropower potential, which the three countries are seeking to harness for national development. Transboundary cooperation can therefore optimize the value of water across the 3S.

A nexus assessment[112] of the 3S basin, carried out as part of the BRIDGE project, identified three areas of transboundary cooperation: joint energy planning and investment to maximize river connectivity; transformation of coffee production in Viet Nam to achieve higher value and lower water consumption, thereby increasing dry season water flow into Cambodia; and continued efforts to ensure the Sekong tributary remains free-flowing in order to sustain regional fisheries and food security. Coordinated transboundary investments can deliver energy security, meet export targets and minimize impacts on fisheries.[113] The agricultural (coffee) transformation will cost $300 million over 30 years, increase crop value by 2.5 times and save 200 million m^3 of water in dry season.[114] The energy implications are considered in the "Cumulative Impact Assessment of Renewable Energy in the Sekong", carried out by the International Finance Corporation (IFC) for the Government of Lao PDR to identify the best balance between renewable energy development and the sustainable use and protection of the Sekong River.

The main challenge to implementing the assessment recommendations was the lack of an institutional counterpart with the authority to lead transboundary cooperation in the 3S basin, taking into consideration the relevant, affected sectors. A regional Technical Advisory Group was therefore set up to provide technical input and help disseminate the results of the assessment by engaging with influential organizations such as the IFC, the World Bank, the Communist Party of Viet Nam and ministries of energy, and by framing the key recommendations in economic rather than biodiversity terms.

The nexus assessment, which builds on previous work by IUCN, the Worldwide Fund for Nature (WWF), the Natural Heritage Institute and others, contributed to national energy policy and regional energy development. In 2020, Cambodia issued a 10-year moratorium on Mekong mainstream dams;[115] meanwhile, in Viet Nam, "Resolution 55"[116] issued the same year broke with the coal-first paradigm by prioritizing renewables, while the new Power Development Plan (PDP 8), which is based on the resolution, includes substantial cross-border energy trade – one

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111 "3S Nexus assessment in Cambodia, Lao PDR, Viet Nam", presentation by Jake Brunner, IUCN. Available at: https://unece.org/environmental-policy/events/task-force-water-food-energy-ecosystems-nexus.

112 IUCN, *Measuring, Understanding and Adapting to Nexus Trade-offs in the Sekong, Sesan and Srepok Transboundary River Basins* (IUCN, Gland, Switzerland, 2019). Available at: https://portals.iucn.org/library/sites/library/files/documents/2019-024-En.pdf.

113 IUCN, *Sekong, Sesan and Srepok River Basin Energy Profile* (Gland, Switzerland, 2020). Available at: www.iucn.org/news/viet-nam/202005/sekong-sesan-and-srepok-river-basin-energy-profile.

114 IUCN, *Transforming Coffee and Water Use in the Central Highlands of Vietnam: Case Study from Dak Lak Province* (Gland, Switzerland, 2020). Available at: www.iucn.org/news/viet-nam/202008/transforming-coffee-and-water-use-central-highlands-vietnam-case-study-dak-lak-province.

115 *Reuters*, "Cambodia halts mainstream Mekong River dam plans for 10 years, official says" (2020). Available at: www.reuters.com/article/us-mekong-river-cambodia-idUSKBN215187.

116 Baker McKenzie, "Vietnam's Politburo issues resolution on orientation of new national energy development strategy to 2030 with a vision to 2045" (2020). Available at: www.bakermckenzie.com/en/insight/publications/2020/02/vietnam-national-energy-development-strategy.

of the recommendations of the assessment.[117] Furthermore, the IFC is now linking financing for power transmission with keeping the Sekong free-flowing.

EcoPeace Middle East: Synergic transboundary solutions for the water-energy nexus

Riparian countries: *N/A (the case does not refer to a transboundary basin)*

Sectors: *water, energy*

Problems tackled: *water scarcity (climate resilience, energy security)*

Success factors in focus: *regional trade (energy and water)*

Financing sources: *N/A (solution at the proposal stage, targeting the private sector)*

Financing delivery pathways: *(solution at the proposal stage)*

Transboundary cooperation framework and/or project: *N/A (the case does not refer to a transboundary basin)*

EcoPeace Middle East is an environmental NGO that brings together Israeli, Jordanian and Palestinian environmentalists. The Water-Energy Nexus (WEN) is EcoPeace's flagship project for climate change adaptation and mitigation, designed to create a regional desalinated water and solar energy community for Israel, Jordan and the State of Palestine that would optimize the use of resources and support healthy and sustainable regional interdependencies.

The possibility to transfer desalinated water from Israel and the State of Palestine, which have access to the Mediterranean Sea, in exchange for solar energy produced in Jordan, which has an abundance of available land for photovoltaic and wind, was the subject of a pre-feasibility study in 2017. The study showed that "*the proposed idea of international cooperation and water-energy exchanges, while facing political obstacles, could provide numerous economic, environmental and geopolitical benefits to all parties involved*".[118] Such a cooperative arrangement, the study found, would likely be a more efficient way of using the available resources than developing desalination and renewable energy processes in different territories in isolation. In 2020, EcoPeace released an additional report calling for a Middle East Green Blue Deal, where the water energy proposal features prominently.[119] Following the release of this report, the project obtained extensive private sector and government support.

Any such type of synergetic water-energy solution would require cooperation to be strengthened between the two sectors at the national level. In this regard, a recent study shows that Jordan's water and energy sectors are increasingly connected though cooperation with a focus on technical solutions and resource allocation decisions.[120]

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117 Global Compliance News, "Vietnam: Key highlights of new draft of national power development plan (Draft PDP8)" (2021). Available at: https://globalcompliancenews.com/vietnam-key-highlights-of-new-draft-of-national-power-development-plan-draft-pdp8-04032021-2.

118 David Katz and Arkadly Shafran, "Transboundary exchanges of renewable energy and desalinated water in the Middle East" (*Energies*, 2019) vol. 12, no. 8, p. 1455. Available at: www.mdpi.com/1996-1073/12/8/1455.

119 Gidon Bromberg and others, *A Green Blue Deal for the Middle East: Eco-Peace* (Tel Aviv, Ramallah, Amman, 2020). Available at: https://old.ecopeaceme.org/wp-content/uploads/2021/01/A-Green-Blue-Deal-for-the-Middle-East-EcoPeace.pdf.

120 Jonathan Chenoweth and Raya A. Al-Masri, "The impact of adopting a water-energy nexus approach in Jordan on transboundary management" (*Environmental Science & Policy*, 2021) vol. 118, April, pp. 49–55. Available at: www.sciencedirect.com/science/article/abs/pii/S1462901121000265.

The Alazani/Ganykh River Basin: Considering nexus solutions in national, regional and basin planning (experience of Georgia)

Riparian countries: *Azerbaijan and Georgia*

Sectors: *water, agriculture, energy, environment*

Transboundary problems tackled: *water quantity, water quality, environment*

Success factors in focus: *increased awareness of benefits accruable to cross-sector, transboundary trade-offs, compromise and synergies*

Financing sources: *the state (including credits from development partners and development partner grant support), blended finance, the private sector*

Financing delivery pathways: *project-specific, specific programme financing, sector budget support, central budget support*

Transboundary cooperation framework and/or project: *UNDP-GEF Kura Project (which supported the nexus assessment by facilitating transboundary dialogue*

The Alazani/Ganykh River is of great social and economic importance for both Azerbaijan and Georgia. The two countries have participated in a number of regional projects focused on the management, monitoring and assessment of transboundary water resources, including the Alazani/Ganykh participatory assessment of the water-food-energy-ecosystems nexus (2013-2014), which was facilitated by UNECE and UNDP.[121]

The assessment found multiple linkages among the different basin resources, including chains of indirect impacts across sectors, for example between household use of fuelwood, deforestation, erosion and sedimentation, loss of ecosystem services and degradation of the hydrological regime. Potential solutions to increase benefits from the basins' resources were also explored, and according to the assessment could be achieved through more coordinated policies and actions and transboundary cooperation. Such potential solutions include facilitating access to modern fuels (such as gas) and to energy trading; introducing economic instruments; improving the sustainability of hydropower generation; and developing the agriculture and agro-industrial sector, for example by improving the maintenance of irrigation infrastructure.

These approaches are reflected in a number of measures being taken by the Government of Georgia at the national and basin level, including: the adoption of resolutions, the elaboration of national socio-economic development plans and the development of new legislation for the Kakheti region. In terms of basin-level strategies, the objective is to improve living conditions and ensure sustainable access to sufficient food, water, energy and environmental resources. From 2013 to the present, about 50 000 new consumers in 178 villages across 8 municipalities of Kakheti have been connected to the gas network, a process financed by the government and implemented by the Georgian Gas Transportation Company.

The nexus assessment also informed the following sectoral and cross-sectoral strategies: the "Strategy of socio-economic development of Georgia (Georgia 2020)", the "Strategy of socio-economic development of Kakheti for the period 2014-2021", the "The third programme of environmental activities of Georgia for 2017-2021 (NEAP-3)", the "National Action Plan for Environment and Health for 2018-2022 (NEHAP-2)", the "Strategy for the Development of Agriculture for 2015-2020", the "Strategy for the Development of Georgia's Villages for 2017-2020", the "National Renewable Energy Action Plan (NREAP) for 2019-2020" and others. Additionally, the National Energy And Climate Plan 2021-2030 (under development at the time of writing) includes a chapter on decarbonization in line with the NREAP. All these documents are the result of comprehensive, coordinated, intersectoral work on the part of ministries.

[121] The findings from the assessment are included in UNECE, *Reconciling Resource Uses in Transboundary Basins: Assessment of the Water-Food-Energy-Ecosystems Nexus* (UNECE, Geneva, 2015). Available at: https://unece.org/environment-policy/publications/reconciling-resource-uses-transboundary-basins-assessment-water.

All the above-mentioned activities can be coordinated (and lessons shared) across the border through joint working groups established within the framework of the UNDP-GEF Kura Project on water quality and quantity, which meets regularly. The results of this project will be used to strengthen the foundations for the implementation of IWRM, and support the harmonization of legal, institutional and regulatory documents within and between the countries for more effective management of the common river basin.

The Dniester River: Optimizing ecological flows of a hydropower plant

Riparian countries: *Republic of Moldova and Ukraine*

Sectors: *energy, environment*

Transboundary problems tackled: *water quantity, environment*

Success factors in focus: *institutional arrangements*

Financing source: *development partner grants (GEF)*

Financing delivery pathways: *project specific*

Transboundary cooperation framework and/or project: *the Commission on Sustainable Use and Protection of the Dniester River Basin*

The release of so-called "spring ecological water" from the Dniester reservoir started in 1988, immediately after the commissioning of the Dniester hydropower plant (HPP) in Ukraine, an event that significantly changed the hydrological regime of the river. The spring ecological water release is established under the rules of operation of the Dniester HPP reservoirs. The main objectives of the release are to provide water for fish spawning areas in flood plains, particularly phytophilous fish species, as well as water for animals and plants of the Lower Dniester floodplains, which encompass three Ramsar sites and a national nature park.

The release is conducted every April for a duration of 30 days. The volume and duration of the release depend on the spring flood in the Dniester basin. An Intersectoral Commission under the auspices of the State Agency for Water Resources of Ukraine (SAWRU) is responsible for convening a broad-based discussion and subsequent approval of the release. During the release, the Dniester plant reduces power production and other power producers take over to ensure balanced output across the country's power system.

In 2020, an "analysis of the goals, limitations and opportunities for optimizing the regime of spring ecological reproductive release from the Dniester reservoir" was performed upon the joint request of the governments of the Republic of Moldova and Ukraine. The analysis provided several scenarios and models of the spring ecological water release. Hydrobiological studies and modelling were also conducted.[122]

The study highlighted the need for the following joint actions in regard to the spring ecological water release:

- the development of tools to monitor the effectiveness of the release;
- further analysis to understand the objectives, limitations and efficacy of the release;
- a change in the procedure for submitting proposals to the Intersectoral Commission that consider realistic scenarios based on agreed long-term requirements and limitations; and
- the strengthening of mechanisms for transboundary agreement on the parameters of the release within the framework of the Commission on Sustainable Use and Protection of the Dniester River Basin (the Dniester Treaty 2012)[123] and the Institute of the Plenipotentiaries (the Dniester Agreement of 1994).[124]

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[122] The GEF/UNDP/OSCE/UNECE project "Enabling transboundary co-operation and integrated water resources management in the Dniester River Basin" has provided the requested expertise and funds. Documents and the interactive tool for release flow scenarios are available at: https://dniester-commission.com/en/news/the-experts-examined-optimization-options-for-spring-ecological-reproductive-release-from-the-dniester-reservoir (In English) https://dniester-commission.com/novosti/eksperty-izuchili-varianty-optimizacii-vesennego-ekologo-reprodukcionnogo-popuska-iz-dnestrovskogo-vodoxranilishha (In Russian).

[123] Treaty between the Government of the Republic of Moldova and the Cabinet of Ministers of Ukraine on Cooperation in the Field of Protection and Sustainable Development of the Dniester River Basin, signed by the Minister of Environment of the Republic of Moldova and the Minister of Ecology and Natural Resources of Ukraine in 1992.

[124] Agreement between the Government of the Republic of Moldova and the Government of Ukraine on the Joint Use and Protection of Border Waters, signed in 1994.

Accordingly, more needs to be done to optimize ecological flows, in particular as environmental needs are the only element of the "water balance" of the basin that remain unclear, even though the different needs of all sectors are known. This requires new resources and capacity as water authorities in Moldova and Ukraine are often overloaded and lack the necessary funds to carry out this type of research. However, the political momentum exists as the countries are committed to reviewing flow release parameters at the transboundary level beyond the spring release (all year operations).[125]

This case study demonstrates that water-energy-environment dialogue at the transboundary level can facilitate agreement on measures to better reconcile different flow-related needs and reduce the environmental impact from economic activity.

5.4 Infrastructure and innovation

This section includes three case studies. The first focuses on the Skadar/Shkoder Lake (part of the Drin River Basin) and illustrates how a small-scale renewable energy nexus solution can contribute to the implementation of both national and transboundary plans. The second case study on the Drina River Basin details the assessment and estimated investment needed to tackle the problem of erosion through multiple sectoral actions. The last case study on the Trifinio water fund explores the possibility of financing watershed conservation through payments from nexus sectors.

The implementation of infrastructural nexus solutions is increasingly common, although they are rarely designed as transboundary projects. Basin plans and programmes could well include infrastructural nexus solutions (green and grey), and such solutions could potentially be implemented across borders. The importance of nature-based solutions for climate change adaptation is a case in point,[126] and renewable energy solutions to reduce the environmental impact on rivers is another.[127]

The implementation of land-based infrastructure solutions for the benefit of water and the environment requires coordination with the forestry or agriculture sector. A recent paper[128] provided various applications of innovative soil engineering as a green-infrastructure solution for the sustainable management and use of nature, including as a means to address socio-environmental challenges such as climate change, water security, water pollution, food security, human health and disaster risk management. The importance of these applications in transboundary basins is clear, although these projects are typically implemented at local level. The study suggests that the impact of these solutions would perhaps be strengthened through the integration of engineering components (e.g. standards, best practice, etc.) into existing policy instruments at national and transnational levels.

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125 OSCE, Analysis of the Goals, Limitations and Opportunities for Optimizing the Regime of Spring Ecological Reproductive Releases from the Dniester Reservoir (OSCE, Helsinki, 2020).

126 UNECE, "Advancing ecosystem-based adaptation to climate change in transboundary basins" (UNECE, Geneva, 2019). Available at: https://unece.org/environment/news/advancing-ecosystem-based-adaptation-climate-change-transboundary-basins.

127 WWF & TNC, Connected and Flowing (Gland Switzerland, WWF, 2019); UNECE, Towards Sustainable Renewable Energy Investment and Deployment: Trade-offs and Opportunities with Water Resources and the Environment (UNECE, Geneva, 2020).

128 Slobodan B. Mickovski, "Re-thinking soil bioengineering to address climate change challenges" (*Sustainability*, 2021) vol. 13, no. 6. Available at: www.mdpi.com/2071-1050/13/6/3338/htm.

Skadar/Shkoder Lake (Drin River Basin): Energy recovery from biomass of invasive species removed from a shared lake

Riparian countries: *Albania and Montenegro (Skadar/Shkoder Lake); Albania, Greece, Kosovo,*[129] *Montenegro, North Macedonia (the Drin River)*

Sectors: *water, energy, environment*

Transboundary problems tackled: *water quality, environment*

Success factors in focus: *renewable energy, innovative financing*

Financing source: *development partner grants (GEF)*

Financing delivery pathways: *project specific*

Transboundary cooperation framework and/or project: *Memorandum of Understanding (MoU) for the management of the extended transboundary Drin Basin*[130]

A small-scale nexus solution was implemented as a pilot activity, entitled "Reduction of nutrient load and forest preservation through biomass collection and production of fuel briquettes in the Montenegrin part of the Skadar/Shkoder Lake", within the framework of a GEF Drin Project.[131] The transboundary Skadar/Shkodra Lake is shared by Albania and Montenegro.

The solution tackles problems of water quality (eutrophication) and environment (invasive species) while generating new benefits (biomass) to make the solution economically self-sustainable. The biomass collected to clean-up the lake is used to produce fuel-briquettes: a valuable alternative source of energy to fuelwood, the use of which is unsustainable and widespread across the region. The pilot was implemented in conjunction with the National Park Authorities and informed their approach for managing invasive species in the future.[132] Specifically, the project aimed to:

- improve knowledge regarding specific ecosystem changes caused by extensive nutrient load;
- implement targeted vegetation control measures (wetland management);
- reduce nutrient load from the lake (primarily phosphorous and nitrates) by removing biomass, notably reed and the invasive species Indigo bush (*Amorpha fruticose*), known locally as "bagremac";
- decrease pressure on degraded natural forest on the lakeshore by reducing logging, and testing possibilities for the use of fuel briquettes produced from harvested biomass as an alternative to woodfuel;
- help improve socio-economic conditions at the local level by exploring and creating potential for additional employment opportunities (through biomass-to-fuel schemes) and supporting tourism (boat cruising, recreational activities); and
- enhance knowledge among the local population of the importance of sustainable management of the lake.

This solution contributes to improving the state of the lake ecosystem by establishing a replicable, low-cost approach that provides multiple benefits without generating negative impacts. When scaled up, this solution contributes to CO_2 emission reduction and job creation. Importantly, the pilot is designed to support a financially self-sustainable activity that produces mitigation measures benefiting the community, nature and natural park management at no additional cost.

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129 UN Security Council Resolution 1244.

130 The Drin Memorandum of Understanding was signed in Tirana on 25 November 2011 by the Ministers of the water and environment management competent ministries of the Drin Riparian states (i.e. Albania, North Macedonia (then Former Yugoslav Republic of Macedonia), Greece, Kosovo (UNSCR 1244/1999) and Montenegro.

131 The project is implemented by UNDP and executed by Global Water Partnership-Mediterranean in partnership with UNECE. The project webpage is available at: http://drincorda.iwlearn.org/library-main/meetings/inaugurations/biomass-pilot-activity-in-national-park-of-skadar-lake-reaches-second-phase-following-equipment-donation.

132 Ibid.

The pilot – and its potential for upscaling or replication – contributes to the implementation of the following policies and plans at the national level (Montenegro):[133]

- the National Forest Strategy, which promotes investments for the sustainable forest management of private and state forests;
- the National Renewable Energy Strategy, which promotes the use of energy efficient technology such as biomass boilers;
- the forestry policy, which emphasizes the need for research on the role of forests in mitigating climate change, ensuring a functioning forest ecosystem, protecting biodiversity, regulating the use of timber and biomass, establishing a balance between forest and water needs, and promoting economic competitiveness and rural development.

At the transboundary level, the pilot contributes to implementation of the Strategic Action Programme of the Drin River Basin,[134] which includes energy and forest-related actions and incorporates recommendations from the Nexus Assessment of the Drin.[135]

Drina River Basin: Coordinated actions to manage sediment and control erosion

Riparian countries: *Bosnia and Herzegovina, Montenegro and Serbia (a very small part of Albania)*

Sectors: *water, agriculture, energy, environment, industry, navigation, tourism*

Transboundary problems tackled: *environment*

Success factors in focus: *natural infrastructure*

Financing source: *actions not yet funded; study funded by the state including development partners (UNECE)*

Financing delivery pathways: *N/A (actions not yet funded)*

Transboundary cooperation framework and/or project: *International Sava River Basin Commission and the Drina Nexus Assessment*[136] *and a follow-up project under the Water Convention*[137]

The Drina River Basin is naturally prone to erosion which impacts a variety of sectors including energy, water and agriculture. In order to address this issue, the Jaroslav Černi Water Institute in Serbia developed a "Scoping study on erosion and sedimentation in the Drina River Basin",[138] which used available data from the three basin-sharing countries to provide a consistent picture of sedimentation and erosion in the basin and related problems (sedimentation of reservoirs, sedimentation of river mouths, problems with erosion deposition/flooding in downstream areas, etc.).

The recommendations from the study are cross-sectoral in nature, in particular with regard to applying and monitoring appropriate erosion control measures, applying measures to reduce erosion and torrent impact in a coordinated fashion, applying biological and biotechnical measures, and exploring synergies, for example among flood control, forestry actions and biomass production, where appropriate. Based on this study, the investments needed for anti-erosion and torrent control are estimated at €113 million.

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133 Study by CNVP on "Strengthening the value chain of energy biomass in the Drin River Basin for a more sustainable management of forests, and related nexus implications" (included in UNECE and GWP-Med, *Drin Nexus Assessment*, forthcoming).

134 The Drin Strategic Action Programme was endorsed by ministers and high-level representatives of the Drin Riparian states during an online ceremony on 24 April 2020. Available at: http://drincorda.iwlearn.org/gef-supported-drin-project/the-drin-strategic-action-programme.

135 Phase II Nexus Assessment in the Drin basin. Information available at: www.gwp.org/en/GWP-Mediterranean/WE-ACT/Programmes-per-theme/Water-Food-Energy-Nexus/seenexus/drin-II.

136 UNECE, Assessment of the Water-Food-Energy-Ecosystem Nexus and Benefits of Transboundary Cooperation in the Drina River Basin (United Nations, Geneva, 2017).

137 "Background on the work on the water-food-energy-ecosystems nexus on the Sava and the Drina, and the Drina River Basin Concept Note of the Phase II Nexus Assessment Report", presentation by Annukka Lipponen (2021). Available at: www.gwp.org/globalassets/global/gwp-med-files/list-of-programmes/see-nexus/phase-ii-ada-nexus/unece--nexus-on-the-sava-and-the-drina-and-cn-phase-ii_mne.pdf.

138 One of the components of the UNECE Drina River Basin Nexus follow-up project. Available at: https://unece.org/environment-policy/water/areas-work-convention/water-food-energy-ecosystem-nexus.

In this case, the nexus approach helped to connect different countries in the basin as well as many of the sectors concerned, although communication among countries and sectors is still inadequate. The process of taking stock of nexus solutions also enabled the solution to be presented to potential partners in an online consultation meeting where nexus investments in the Western Balkans and associated financing opportunities were discussed.[139] However, persistent financial constraints mean that substantial help from international financial institutions and other organizations is required to implement the measures proposed by the study.

Trifinio water fund: Innovative financing for watershed conservation

Riparian countries: *El Salvador, Guatemala and Honduras*

Sectors: *water, agriculture, energy, environment, industry, tourism*

Transboundary problems tackled: *water quantity, environment*

Success factors in focus: *innovative financing*

Financing source: *TBD (project under development)*

Financing delivery pathways: *water fund (under development)*

Transboundary cooperation framework and/or project: *Plan Trifinio*

The Trifinio region is an "indivisible ecological unit" situated at the confluence of the Lempa, Motagua and Ulúa rivers, and is home to about 1 million people. This biosphere is a shared, and jointly managed, natural reserve with significant natural and cultural/archaeological touristic potential. El Salvador, Guatemala and Honduras cooperate on the management of shared resources through the Trinational Commission, established in 1997, which is responsible for implementing the development plan for the basin region (Plan Trifinio).[140]

A "water fund" is a financial mechanism for watershed conservation activities and projects, as well as a governance mechanism for watershed planning. Water funds apply the principle of Payments for Ecosystem Services (PES) in a watershed to direct payments from downstream users and beneficiaries of watershed services to sustain upstream communities and ecosystems.

The Trifinio Water Fund, which is currently being developed by the Commission with the support of the Inter-American Development Bank (IADB), would be the first example of a transboundary water fund, where the water users include domestic water supply as well as agriculture (irrigation and fishery), energy (hydropower) and industry.[141] The water fund would direct payments for water and water services (tariffs and permits) towards efforts to sustain shared water and forest ecosystems in the biosphere.

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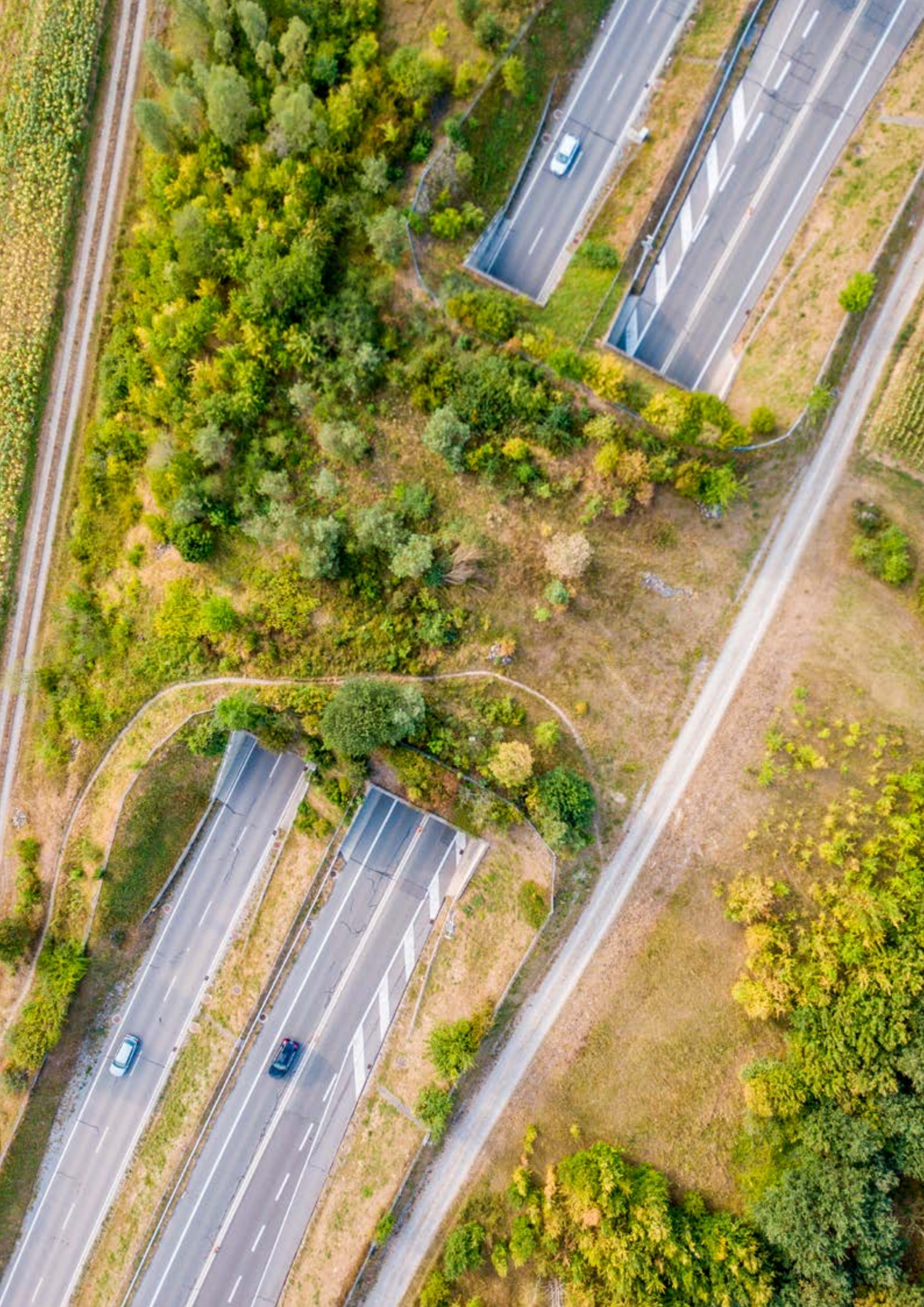
[139] Virtual meeting on Nexus Solutions and Investments in the Western Balkans. Online event organized by UNECE, GWP-Med and EIB on 5 May 2021. Information at: www.gwp.org/en/GWP-Mediterranean/WE-ACT/News-List-Page/2021/nexus-solutions-meeting.

[140] The "Plan Trifinio" Treaty was signed in 1997 between the Republics of El Salvador, Guatemala and Honduras. The treaty institutionalizes the Trinational Commission of the Plan Trifinio.

[141] "Transboundary Waters and Nexus", presentation by Raul Munoz Castillo on 22–23 October 2020 at the sixth meeting of the Task Force on Nexus under the Water Convention (UNECE, Geneva, 2020).



6. ENABLING AND UPSCALING NEXUS SOLUTIONS IN TRANSBOUNDARY BASINS

Enabling nexus solutions means tackling constraints that stakeholders commonly experience when implementing nexus approaches (see section 3.2). The mobilization of new financial resources can represent an important stimulus for cooperation, directly overcoming financial constraints and indirectly improving the technical capacity of institutions to plan "bankable" solutions involving different sectors. However, no nexus solution can be found or implemented without greater coherence at the level of policy action and plans, a requirement that encompasses political dialogue, adequate institutional/governance frameworks and structures, better information, and the search for common objectives, synergies and possibilities for benefit sharing. This is the key to build a common understanding and mutual trust.

6.1 Mobilizing finances for nexus projects

Nexus projects are multi-sectoral in character and require cross-sectoral cooperation to unlock investments. In order for countries to identify nexus opportunities, they must have an overview of planned investments and the types of projects and associated financing at all levels (international, national and local). This enables them to maximize opportunities and minimize risks. However, the level of investment varies among the various components of the water-food-energy-ecosystem nexus, with energy tending to receive a larger proportion of financing compared, for instance, to sanitation.

These differences between sectors create opportunities for multisectoral projects to provide new and additional financing opportunities for water management and contribute to conservation or environment protection objectives through the actions of economic sectors. This approach requires strengthening the capacity of institutions at national and local level to design and manage cross-sectoral projects, including by developing necessary partnerships, and to enhance the implementation of IWRM.[142]

The survey (section 2.4) shows that while the nexus approach opens up opportunities for more private and blended finance, this potential is largely unutilized in transboundary basins. In general, the diversification of financial sources for financing transboundary cooperation can be hampered by risks often associated with cooperation arrangements and institutional set-ups. These are linked to the capacity of institutions to provide an enabling environment and to the extent of interaction between river basin organizations and the private sector (typically low or lacking).

Financing institutions are increasingly concerned with the cross-sectoral coherence of projects in regard to transboundary basins. For example, the World Bank supports the identification of projects with multi-sectoral benefit potential in Africa (see the Zambesi case study) and the implementation of investments across different sectors and countries under a coherent water cooperation framework in South-East Europe (see the Sava-Drina case study). In Latin America and the Caribbean (LAC), the Inter-American Development Bank (IADB) strategy for transboundary waters[143] includes knowledge, science and technical assistance to catalyse nexus (cross-cutting/multisector) investment portfolios, and policy and planning that can be funded by IADB itself or through blended resources with other international finance institutions (IFIs) or private sector. However, it can be noted that in order to promote nexus projects, the IADB leans towards programmatic approaches rather than stand-alone projects (confirming the findings from the survey).

Experience from LAC suggests that adopting a nexus approach to basin planning can be a strategic means to access funding (see the Latin America case study). In Central Asia, the IFC proposes a landscape approach to the evaluation of projects with a view to de-risking investments (see the River basins in Asia case study). The Organisation for Economic Co-operation and Development (OECD) also promotes a similar approach to water investment planning for regional water, food and energy security (see the Lower Syr Darya case study). In the Mediterranean region,

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142 Virtual event organized by UNECE in cooperation with the United Nations Economic Commission for Latin America and the Caribbean (ECLAC) and the Inter-American Development Bank (IADB) on 22 February 2021. More information at: www.water-energy-food.org//news/nexus-blog-virtual-meeting-of-experts-on-policies-of-the-water-food-energy-ecosystems-nexus-and-projects-of-transboundary-relevance-in-latin-america-and-the-caribbean-lac.

143 Joined by Water (JbW), *IDB's Transboundary Waters Program*, IDB Discussion Paper (IADB, Washington, DC, 2021). Available at: https://publications.iadb.org/en/joined-water-jbw-idbs-transboundary-waters-program.

the Union for the Mediterranean takes a nexus approach to financing water investments in order to identify and leverage resources in nexus sectors (energy, agriculture) and the private sector, and to establish partnerships to mobilize climate financing in the region.[144] One example from the Middle East (implemented at national level) illustrates the practical implementation of a nexus solutions and investment project (see the Jordan case study).

Finally, there are perspectives for climate funding to support nexus projects in transboundary basins, for instance through the Green Climate Fund (GCF). This is the largest fund for climate finance, established to support climate change adaptation and mitigation for developing countries and implementation of their National Determined Contributions (NDC). So far, only a few nexus and/or transboundary GCF project proposals have been forthcoming. One example of a transboundary GCF project (under preparation) is Lake Chad & Adaptation to Climate Change (LACC). This project incorporates adaptation and mitigation measures into agriculture and forestry through improved management of water and soil resources, where possible using solar energy.[145] Transboundary partnership discussions and dialogue are crucial here both for the determination of beneficiaries' needs and for the formulation of appropriate adaptation measures. Nexus analysis can also be useful for studying the impact of climate change and investigating policy measures for adaptation and mitigation. Lastly, many ways exist to finance nexus solutions/actions ranging from traditional to innovative finance mechanisms. These different sources can become decisive co-funding opportunities for GCF projects.

Zambesi: Multi-sector investment opportunity analysis

The Zambesi River Basin is shared by Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia and Zimbabwe, and represents a vital source of water and a critical ecosystem for these riparian states and beyond. The economies of the riparian states are dependent on the basin for water, food security and energy, with hydropower production representing a high share of total power production. In this context, climate variability can have devastating effects.

In 2010, the World Bank conducted a Multi-Sector Investment Opportunity Analysis (MSIOA) on the Zambesi River Basin to evaluate different scenarios of water resource development in economic terms and to illustrate the potential benefits of cooperation from a national and basin perspective. The MSIOA indicated that cooperative basin development within the wider Southern Africa Development Community (SADC) has the potential to accelerate both regional economic growth and stability.[146]

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144 UfM, *UfM Financial Strategy for Water* (Barcelona, UfM, 2019). Available at: https://ufmsecretariat.org/wp-content/uploads/2019/04/UfM-Financial-Strategy-for-Water_for-web-paginas.pdf.

145 Green Climate Fund, *LACC Project: Lake Chad & Adaptation to Climate Change*. Concept Note (Green Climate Fund, Incheon, South Korea, 2019). Available at: www.greenclimate.fund/sites/default/files/document/23120-lacc-project-lake-chad-adaptation-climate-change.pdf.

146 World Bank, *The Zambezi River Basin. A Multi-Sector Investment Opportunities Analysis*, Volume 1 Summary Report (World Bank, Washington, DC, 2010) Available at: https://openknowledge.worldbank.org/bitstream/handle/10986/2958/584040V10WP0Wh1LIC100Summary0Report.pdf?sequence=1&isAllowed=y.

The MSIOA assessed methods to manage development in the basin to increase agricultural yields, hydropower output and economic opportunities, based on cooperative efforts to tackle water use efficiency, environmental sustainability, water demand management, and flood and drought mitigation. By comparing different scenarios, the MSIOA was able to provide insights into the strengths and weaknesses of different scenarios (combinations of investments in hydropower, irrigation schemes and floodplain restoration), always ensuring that priority is given to domestic water supply and environmental needs (the latter to the extent possible, based on the available information). The most preferable scenarios are those that fall within the so-called "desirable development zone", which reflect situations where investments in power generation and irrigation are well balanced and address the goals of increasing power generation and direct employment, as well as other needs. As the economic analysis suggests, cross-sectoral impacts can be significant and scenarios that do not account for them are not suitable pathways to sustainable development.

One of the lessons that emerges from this study is that changes in the operational rules of hydropower dams can increase benefits in other sectors (irrigation and flood control), but may also affect energy security during dry periods, which in turn suggests that the diversification of the energy mix can become a key enabler of climate resilience. If diversification is achieved through non-hydro renewable energy, it also contributes to low-carbon development, the economic growth of new sectors, and the "modularization" and modernization of the power system.[147]

Sava-Drina: The Sava and Drina Rivers Corridors Integrated Development Programme

The Sava and Drina Rivers Corridors Integrated Development Programme (SDIP)[148] is a programme financed by the International Bank for Reconstruction and Development (IBRD) and co-financed by the Global Environmental Facility (GEF) and the Western Balkans Investment Framework (WBIF). The SDIP aims to support integrated water cooperation by investing in infrastructure improvements and complementary measures that take into account the current and expected impacts of climate change. Specifically, the project intends to address climate change-exacerbated risks of floods and drought, thereby increasing the resilience of residents and economic activities in the targeted areas. Given the transboundary nature of the basin, this objective will require coordinated development and management of shared water resources in riparian states (Bosnia and Herzegovina, Croatia, Montenegro, Serbia and Slovenia). Broadly, SDIP will invest in the following areas:

- **Inland waterway transport**. Upgrading the navigability of the Sava waterway is a priority, and includes – as a pre-requisite – the removal of mines from the Sava's right bank within Bosnia and Herzegovina. Investment is also vital to modernize ports along this corridor in order to improve market access, and reduce transport and logistics costs to and from lagging and leading regions. This includes support for climate change mitigation through reductions in greenhouse gas emissions and local pollutants associated with the transportation of freight. Over the long term, these investments will also facilitate regional trade across countries.

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147 IUCN, *Increasing Returns on Investment Opportunities by Applying a Nexus Approach: Best Practice Nexus Case Studies* (IUCN, Belgrade, 2019). Available at: https://portals.iucn.org/library/sites/library/files/documents/2019-047-En.pdf.

148 The World Bank Sava and Drina Rivers Corridors Integrated Development Program (P168862). Project Information Document (PID). Appraisal Stage (updated 16 February 2020). Available at: https://documents1.worldbank.org/curated/en/782831582048365750/pdf/Project-Information-Document-Sava-and-Drina-Rivers-Corridors-Integrated-Development-Program-P168862.pdf.

- **Environmental asset management and development**. In parallel, the design of underlying navigation infrastructure interventions, such as dredging, riverbank protection and river training works, will be reviewed and adapted to also protect floodplains and revitalize wetlands. Such multi-purpose interventions would boost sustainable tourism, including eco-tourism – a sector with large potential for job creation – and enable investments in other sectors such as irrigated agriculture and manufacturing.
- **Flood protection**. Investments will be directed to increase protection against floods (including infrastructure works) as well as boost social and economic resilience to extreme weather events linked to climate change.
- **Regional activities**. The project will support the International Sava River Basin Commission to strengthen strategic regional dialogue, and engage in joint planning as well as sustainable management and development of the shared water resources in the Sava and Drina river basins, including by building resilience to climatic shocks. It will also support policy dialogue, consultations, and the preparation of basin plans and studies, and ensure investments to strengthen the nexus between water services, development and the economic cooperation objectives of the Sava and Drina Corridor.

Phase I of the SDIP (2020–2026) will focus on investments in flood protection and navigation and the preparation of additional transformational, multi-purpose regional investments to be financed under the next phase. Investments in navigation and flood protection will continue under Phase II (2023–2030) and will be joined by additional investment in sectors such as hydropower optimization, environmental improvements, recreation and tourism. This phase will focus on the implementation of sub-projects prepared under Phase I, with a stronger emphasis on multi-purpose, integrated and transboundary investments where relevant.

While the project supports a variety of activities implemented at local, national and international level, these respond to key regional cooperation/transboundary objectives, such as a navigable Sava, as part of the EU Core Trans-European Transport Network (TEN-T) and in accordance with active legal framework agreements notably, the Framework Agreement on the Sava River Basin (FASRB).

River basins in Asia: Landscape Advisory initiatives for basin planning and facilitating private sector investments

The International Finance Corporation (IFC) deploys Landscape Advisory initiatives in various river basins including the Trishuli River Basin in Nepal (shared with the Tibet Autonomous Region in China),[149] the Sekong River Basin in Lao PDR (shared with Cambodia and Viet Nam), the Myitgne River Basin in Myanmar and the Jhelum Poonch River basin in Pakistan (shared with India).

[149] IFC, *Cumulative Impact Assessment and Management: Hydropower Development in the Trishuli River Basin, Nepal* (IFC, Washington DC, 2020). Available at: www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/publications/publications_report_cia-trishuli.

Sectors that depend on the presence of natural resources (e.g. hydropower, wind and solar power and agribusinesses) tend to be geographically concentrated, and thus affect collectively the same environmental and social receptors (e.g. communities, biodiversity, human rights, water and security). The standard approach of assessing risks and impacts through a project lens is inherently limited when companies operate in close proximity. Moreover, companies may not readily share data or collaborate on assessments, leading to duplication of efforts and difficulties with monitoring, as data collection methods often vary. Efforts to address key environmental and social issues during environmental and social impact assessments often come too late for effective management, especially when operating in sensitive environments. Acting earlier in the developmental process enables these risks to be identified at the outset and addressed before decisions are made that may be difficult to change (e.g. the siting and location of infrastructure). This helps to avoid impacts and the need for high-risk, costly mitigations (e.g. offsets), and may also reduce the chances of unexpected delays arising from stakeholder concerns.

When operating in complex environments such as across landscapes within a river basin, environmental, social and corporate governance challenges often surpass the capacity of single companies to respond adequately. In such contexts, Landscape Advisory initiatives help identify how the private sector can improve its performance and cooperate with the government/public sector as well as other developers and NGOs operating in the vicinity to coordinate efforts.

However, cases where no single entity possesses the ability, leverage or technical know-how to convene multiple stakeholders, to collectively address risks and impacts and define solutions, can present a barrier to investment. By deploying Landscape Advisories initiatives, the IFC addresses such situations by working not only to assess risks but also to develop joint management options.

Latin America: Integrating the nexus approach into GEF-IW projects

The Global Environment Facility (GEF) proposes a two-step process to address environmental issues in shared freshwater bodies: the Transboundary Diagnostic Analysis (TDA) and the Strategic Action Programme (SAP). The TDA is a rigorous diagnostic of the issues aimed at mapping the root causes that need to be addressed. The SAP – a document that is adopted at ministerial level and can be implemented through inter-ministerial committees – contains the remedial actions needed both at national and transboundary level. As a strong commitment from the countries, the SAP also touches upon monitoring, policy reforms and investments. However, what can be achieved in practice is influenced by how and to what degree the relevant economic sectors are engaged in the process. The GEF promotes the use of the nexus approach in its strategy without prescribing a specific methodology.[150] Transitioning from science to policy can cause some challenges that the Nexus Approach might help to address.

[150] The GEF-IWLEARN platform, however, offers services and access to tools.

The three following examples of GEF-IW projects in Latin America show how the nexus approach has shaped their design:[151]

The Amazon (Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname and Venezuela)

Formulation of the SAP was a participative process involving technical experts and country representatives, including the Ministries of Foreign Affairs. The scope of the SAP chapter on infrastructure proved to be divisive. In the quest for a solution, the SAP implementation project, recently initiated under a cooperation agreement between UNEP and the Amazon Cooperation Treaty Organization (ACTO), will intensify inter-ministerial and expert dialogues using a nexus approach to examine climate resilience, resilient infrastructure and sustainable energy. By so doing, the project will benefit from the technical know-how of UNECE as well as that of the IADB, who recently signed a technical cooperation agreement with ACTO to develop nexus solutions and investments at transboundary level, also in support of a Regional Water and Sanitation Programme for the basin.

The Pantanal (Brazil, Bolivia and Paraguay)

The TDA and SAP documents were initially developed in 2004, but only for Brazil. Today, they are being revised and their scope expanded to cover all three countries. Use of the nexus approach is seen as critical to untangle complex cross-sectoral and upstream-downstream issues in the basin, and to support the formulation of a robust SAP. While there was initial hesitation on the part of the countries to employ a nexus approach due to its apparent complexity, its acceptance as a critical approach to support transboundary water management of an ecosystem of global significance helped to ensure alignment with the GEF strategy, and therefore access GEF funding, which resulted in project approval in June 2020. The project – which will be co-implemented by UNEP and IADB – is framed within the Trinational Declaration of the Pantanal, signed by the three countries in 2018, and now includes specific components to design nexus solutions in support of the formulation of a trinational TDA and SAP with a solid portfolio of projects for investment.

The Trifinio (El Salvador, Guatemala and Honduras)

In the Trifinio region, the main environmental challenges relate to high water and ecosystem demands to meet the needs of modern agriculture (e.g. coffee) and rapid urban growth (with increased energy and water demands) coupled with a high level of poverty in rural areas, threats to the integrity of ecosystems from mining, and climate change. Tackling these environmental problems requires a complex analysis of interactions; however, in the case of the Trifinio, solid data are already available from previous studies, as the region has an history of collaboration. At the suggestion of UNEP as the Implementing Agency and taking into account the experience of UNECE, the project will also use a nexus approach to inform TDA and SAP formulation and to help countries leap from science to policy across sectors. The project will also look at innovative conservation finance mechanisms such as water funds with the support of IADB, which is financially supporting the design of the world's first transboundary water fund for the Trifinio (see section 5.4) in the context of the Latin American Water Funds Partnership.

[151] Virtual event organized by UNECE in cooperation with the United Nations Economic Commission for Latin America and the Caribbean (ECLAC) and the Inter-American Development Bank (IADB) on 22 February 2021. More information at: https://www.water-energy-food.org//news/nexus-blog-virtual-meeting-of-experts-on-policies-of-the-water-food-energy-ecosystems-nexus-and-projects-of-transboundary-relevance-in-latin-america-and-the-caribbean-lac.

Lower Syr Darya: Prioritizing water sector investments by impact and returns

When planning for water investments, the challenge is to allocate the minimal necessary resources to obtain the maximum net benefits for the country and the broader region. IWRM must include – or be accompanied by – integrated investment planning and may be complemented, where appropriate, by a benefit-sharing mechanism across sectors and eventually between riparian countries. Furthermore, investment planning for water infrastructure would benefit from being informed by bold hydro-economic analysis. Such analysis could include an assessment of net benefits, losers and winners between and within countries and affected sectors (argi-food, energy and water), and affordability issues.

The OECD has supported the Government of Kazakhstan to identify ways to increase returns from existing Multi-Purpose Water Infrastructure (MPWI), starting with the Shardara reservoir and associated water systems in the Lower Syr Darya basin as a pilot case study. This reservoir was built initially for irrigation and to support livestock, and later upgraded to provide hydroelectricity generation, flood control and commercial fisheries. In the future, it is also expected to support recreational activities. However, the site lacks irrigation water in dry years, and local agriculture is characterized by low water efficiency and salinity problems due to a lack of collector-drainage systems. The OECD considered the impact of several possible interventions in the Shardara MPWI with the ultimate goal of improving water, energy and food security in the country and region.[152] The key recommendation was to invest in improving drainage as a priority, as this would substantially increase agricultural land productivity, compared to on-farm water efficiency measures such as drip irrigation that would have a smaller impact, at least at present, and produce lower return on investment.

[152] OECD, *Strengthening Shardara Multi-Purpose Water Infrastructure in Kazakhstan* (OECD, Paris, 2018). Available at: www.oecd-ilibrary.org/environment/strengthening-multi-purpose-water-infrastructure-in-shardara-mpwi-kazakhstan_9789264289628-en.

Jordan: Innovative financing for water-energy nexus solutions

Jordan's As-Samra Waste Water Treatment Plant (WWTP)[153] is an example of a public-private partnership (PPP) for a project providing benefits to water, energy, agriculture and the environment. As-Samra is the first WWTP in the Middle East to use a combination of private, donor and local government financing. This is proof of the advantages of using private sector financing in conjunction with grant funding as part of a scheme known as Viability Gap Funding. The As-Samra WWTP is therefore a model example not only in terms of the technology/knowledge transfer it has achieved, but also in terms of the financing options it has employed to achieve them. This unique financing system has also resulted in affordable tariffs for the community and the country.

The PPP was established initially to finance the construction and operation of a public WWTP infrastructure based on a Build Operate Transfer (BOT) approach, over a period of 25 years. The WWTP brings the following benefits:

- 80 per cent of the energy required for the plant's operations is generated by the plant itself (biogas from sludge, hydropower at the outlet of the plant).
- The treated water is used for agricultural purposes, accounting for about 10 per cent of water consumption in the country. The principal re-users of this water are farmers who irrigate their crops with water from the King Talal Reservoir and other farmers located along Wadi Zarqa. The plant has also contributed to reducing water pollution in Jordan.

By making WWTPs self-sufficient in terms of energy supply, countries can help make their water supplies more secure, as treated water can be used for more applications, thereby reducing the demand on fresh potable water.

Jordan is one of the leading countries in the region to utilize treated wastewater, and reports that 100 per cent of its safely treated wastewater is currently used. The treated wastewater is used mainly by the agriculture sector for irrigation in the Jordan valley and to a lesser extent by industry. This allows for the re-allocation of freshwater resources that would otherwise have been used in agriculture to the domestic sector, without impacting available irrigation water.[154]

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[153] United Nations Economic and Social Commission for Western Asia, Developing the Capacity of ESCWA Member Countries to Address the Water and Energy Nexus for Achieving Sustainable Development Goals: Water-Energy Nexus Operational Toolkit, Technology Transfer Module, E/ESCWA/SDPD/2017/Toolkit.3 (UNESCWA, Beirut, 2017). Available at www.unescwa.org/sites/www.unescwa.org/files/publications/files/water-energy-nexus-technology-transfer-module-english_0.pdf.

[154] United Nations Economic and Social Commission for Western Asia, *UNESCWA Water Development Report 6: The Water, Energy and Food Security Nexus in the Arab Region*, E/ESCWA/SDPD/2015/2 (UNESCWA, Beirut, 2015). Available at www.unescwa.org/sites/www.unescwa.org/files/publications/files/l1500339.pdf.

6.2 Enhancing basin level coherence of policy actions and plans

The nexus approach to transboundary water management and cooperation can help detect inconsistencies in sectoral and national development plans and redefine priorities.[155] For instance, the nexus approach can be used to define packages of nexus solutions that are coherent across sectors (reduced trade-offs and improved synergies), through participatory processes involving all riparian countries (see the NWSAS case study). Similarly, it can help to develop decision-making frameworks to evaluate multi-dimensional trade-offs and benefits with different stakeholder groups (see the Zambesi and Senegal, Mekrou case studies). Globally, the nexus approach has produced several technical assessments and exercises focused on integrated modelling and co-optimization of nexus resources with a transboundary basin focus. These assessments have proven extremely valuable in supporting transboundary dialogue; however, their impact ultimately depends on policymakers actively engaging in these exercises and taking into consideration the results when developing national policies and plans.

River basin organizations (RBOs) have an important role to play in coordinating or participating in this type of dialogue, depending on their mandate (the level of multi-sectoral integration largely depends on the specific mandate of the RBO)[156] and their influence.[157] To fulfil this role, RBOs could, as appropriate, coordinate with other regional organizations (e.g. economic commissions or energy regional organizations) to achieve more effective cross-sectoral outreach and assessment of the cumulative impacts of infrastructure projects (green and grey), which is crucial for project sustainability and climate resilience. For instance, an RBO can offer a platform for nexus assessment (see the Sava case study), provide a space for countries to discuss and coordinate on the implications of different-sector developments (notably in energy and agriculture) on water and ecosystems (see the Mekong case study), support countries to evaluate projects based on the multi-sectoral benefits they provide (see the Niger river basin case study), and assist states in mainstreaming sustainable agriculture for the purpose of improved water quality and in developing common guidelines (see the Danube case study). Clearly, much depends on the availability of resources and capacity, as well as on the willingness of countries to use these platforms to discuss strategic policies and investment plans.

These initiatives are crucial for capacity building at different levels (see the Lake Titicaca case study). Since the root causes of problems may extend beyond hydrological changes and climate change (e.g. data limitation, poor management, the political economy, poor disaster planning, inadequate institutional arrangements, etc.), it is crucial that local, national and inter-governmental institutions build the necessary capacity to cope with the complexity of nexus dynamics beyond the prioritization of projects.[158] In fact, tackling the lack of a nexus perspective at local or national level can also enhance transboundary cooperation and in turn support a transboundary nexus dialogue.

North Western Saharan Aquifer System (NWSAS): A package of nexus solutions

The North Western Sahara Aquifer System (NWSAS) covers an area of 1 million km^2 and is shared by Algeria, Libya and Tunisia. The aquifer is a critical source of water that supports all economic activities including agriculture, which provides the main source of income for a large proportion of the local population. However, the basin is threatened by the degradation and depletion of groundwater resources due to increasing demands and increasing infiltration of pollution from various sources.

The NWSAS nexus assessment (2017–2019) was facilitated by the Global Water Partnership Mediterranean (GWP-Med), the Observatory for Sahara and the Sahel (OSS), and UNECE.[159] The process was supported by the NWSAS Coordination Mechanism, which provides an institutional framework of cooperation between the countries. The main output of the participatory process was a "package of solutions", jointly developed with the countries,

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155 Virtual workshop on financing transboundary cooperation and basin development (16–17 December 2020; organized under the Water Convention). Information at: https://unece.org/environmental-policy/water/events/virtual-workshop-financing-transboundary-water-cooperation-and-basin.

156 See for instance: "A Nexus for Basin Organisations in the Sahel: Multisectoral comparison: OMVS - LCBC - NBA", available at: www.water-energy-food.org/fr/resources/a-nexus-for-basin-organisations-in-the-sahel-multisectoral-comparison-omvs-lcbc-nba.

157 Ines Domborowsky and Oliver Hensengerth, "Governing the water-energy-food nexus related to hydropower on shared rivers—the role of regional organizations" (*Front. Environ. Sci*., 2018). Available at: www.frontiersin.org/articles/10.3389/fenvs.2018.00153/full.

158 Virtual event organized by UNECE in cooperation with the United Nations Economic Commission for Latin America and the Caribbean (ECLAC) and the Inter-American Development Bank (IADB) on 22 February 2021. More information at: www.water-energy-food.org//news/nexus-blog-virtual-meeting-of-experts-on-policies-of-the-water-food-energy-ecosystems-nexus-and-projects-of-transboundary-relevance-in-latin-america-and-the-caribbean-lac.

159 UNECE, "Reconciling resource uses: Assessment of the water-food-energy-ecosystems nexus in the North Western Sahara Aquifer System". Policy brief (UNECE, Geneva, 2020). Available at: https://unece.org/DAM/env/water/publications/WAT_NONE_16_NWSAS_Nexus/NWSAS-UNECE_EN_Web.pdf.

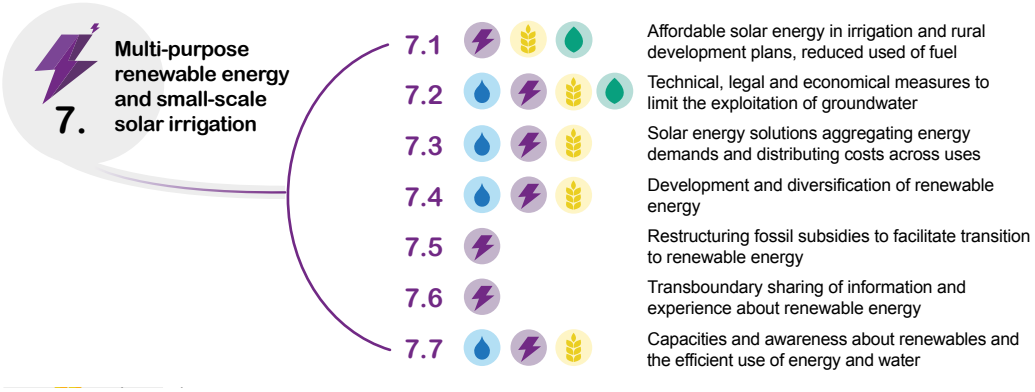
to be implemented through cross-sectoral cooperation. The objective of implementing the solutions in synergy is to enhance the impact of sectoral actions and to ensure their overall coherence towards common objectives of sustainability and development in the basin. Furthermore implementing a nexus approach in the NWSAS can realize a broader range of benefits of cooperation across different sectors and through regional economic cooperation.[160]

The package of solutions includes several actions, some of which have already been at least partially implemented, with the experiences of the countries involved influencing the development of the package. The example shown in Figure 3 illustrates the synergy between an energy-sector led solution (no. 7 of the "package", illustrated in Figure 4), the implementation of which requires coordination with the water, agriculture and environment sectors.

Because of the policy coherence embedded in the coordination of sectoral actions, and the ways in which they can be "packaged", nexus solutions can be used by the countries to:

- draft proposals to international donors interested in financing sustainable development or environmental and climate funds; and
- better coordinate the implementation of water, energy and agricultural policies and projects that have intersectoral impacts.

Figure 3. Coordinated actions across sectors to implement an energy-led nexus solution (NWSAS nexus assessment)[161]



[160] NWSAS Consultation Mechanism, "Benefits of strengthening transboundary water cooperation in North Western Sahara Aquifer System shared by Algeria, Libya and Tunisia", Policy Brief (2020). Available at: https://unece.org/environment/press/policy-brief-highlights-benefits-strengthening-transboundary-water-cooperation.

[161] UNECE, "Reconciling resource uses: Assessment of the water-food-energy-ecosystems nexus in the North Western Sahara Aquifer System". Policy brief (UNECE, Geneva, 2020). Available at: https://unece.org/DAM/env/water/publications/WAT_NONE_16_NWSAS_Nexus/NWSAS-UNECE_EN_Web.pdf.

Figure 4: A package of nexus solutions for the NWSAS[162]

	Water	Energy	Food	Environment
Governance and international cooperation	**1.** Enhance local water management, including revitalising participatory models in oases and enhancing the enforcement of existing laws on water conservation. **2.** Reinforce transboundary cooperation for sustainable groundwater resource management.	**6.** Enhance mechanisms for the coordination of energy development with other sectoral plans, to anticipate trade-offs and build on intersectoral synergies.	**9.** Set up agricultural policies oriented towards rational, sustainable, and productive agriculture. **10.** Valorise local products and strengthen programmes for a more balanced diet while involving young people and women in the economic and social development of the oases.	**13.** Increase awareness of the trade-offs and synergies between different sectors in public institutions.
Economic and policy instruments	**3.** Set up dedicated policies and related incentives for wastewater reuse in agriculture and urban areas. **4.** Strengthen water demand management, including through water-saving programmes.	**7.** Develop a sustainable programme for diversified, multipurpose renewable energy and sustainably upscale small-scale solar irrigation.	**11.** Promote the circular economy including agroecological practices, through ad hoc economic measures and social instruments.	**14.** Consider environmental needs in the water balance of the aquifer.
Infrastructure and innovation	**5.** Upscale the use of non-conventional water resources through desalination and wastewater and drainage treatment.	**8.** Improve the reliability of the electricity grid in rural areas, thereby enhancing the integration of renewable energies for remote and multiple uses.	**12.** Enhance innovative practices and techniques for sustainable soil and crop management and invest in their upscaling and dissemination.	**15.** Systematise environmental and social impact assessment for all new infrastructure (large and small scale).

[162] UNECE, "Reconciling resource uses: Assessment of the water-food-energy-ecosystems nexus in the North Western Sahara Aquifer System". (UNECE, Geneva, 2020). Available at: https://unece.org/DAM/env/water/publications/WAT_NONE_16_NWSAS_Nexus/NWSAS-UNECE_EN_Web.pdf.

Zambesi: Multi-stakeholder dialogue at the transboundary level

The Zambesi River Basin is shared by Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia and Zimbabwe) and is the largest river basin in the Southern African Development Community (SADC).

The Decision Analytic Framework to explore the water-energy-food Nexus (DAFNE) research project was established to explore the water-energy-food nexus in complex transboundary water resource systems of fast-developing countries.[163] By taking a multi- and inter-disciplinary approach to the formation of a decision analytical framework (DAF) for participatory and integrated planning, the project aimed to evaluate decisions based on social, economic and environmental needs.

There are challenges with optimally integrating diverse water uses (hydro, environment and agriculture) into a climate-variable and transboundary context. The project delivered recommendations to the countries, drawing from the principles of international water law and water-energy-food nexus as pathways to achieve the SDGs. The project also illustrates how using the lens of multiple sectors can unlock a greater range of alternatives and benefits. A key tool for these broader aims is alterations to dam operations.[164]

Senegal, Mekrou: the e-Nexus integrated decision support tool

The e-Nexus analytical tool[165] was developed by the Joint Research Centre of the European Commission (JRC) to study the links across the water-energy-food-ecosystem nexus and to develop and apply models specifically tailored to each case study using open source platforms, thereby enhancing local and open data access. The tool includes

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163 DAFNE is an EU-funded "Horizon 2020" project implemented in the Zambesi and the Omo-Turkana Basin (Ethiopia). Information available at: https://dafne.ethz.ch.

164 Julie Gibson and Zeray Yihdego, *Outcomes of the EU Horizon 2020 DAFNE PROJECT The Zambezi River Basin*, University of Aberdeen Policy Brief (2020). Available at: https://uploads.water-energy-food.org/resources/ZRB_Policy-Brief_Aberdeen-University_2020.pdf.

165 JRC, "Position Paper on the Water, Energy, Food and Ecosystem (WEFE) Nexus and the Sustainable Development Goals (SDGs)" (JRC, 2019) https://publications.jrc.ec.europa.eu/repository/handle/JRC114177.

optimization modules for food security and self-sufficiency, cropland management optimization, bioenergy and food security, and water demands assessment. The e-Nexus Decision Support Tool supports the prioritization, validation, development and analysis of resource management options, and simulates the results of intervention plans and investment programmes.

The Senegal river basin is shared by Guinea, Mali, Mauritania and Senegal. The cooperation framework for the riparian states is provided by the Senegal River Basin Development Organization (OMVS). The following issues have cross-sectoral implications: the development of hydropower and multi-purpose infrastructure; improvement of irrigation systems; the impact of high climate variability on rainfed agriculture and flood recession agriculture; navigation improvements to enhance commerce and economic development; environmental protection and the safeguarding of specific ecosystems (e.g. the Delta); the impacts of water quality, especially on health; and the monitoring of groundwater withdrawals for multiple uses.

The ongoing Senegal project[166] aims to support local and regional actors to identify sustainable management measures to address the most pressing issues in the basin, taking into account national policies as well as regional ones (the Water Management Master Plan, the Common Energy Policy, the Energy Transport Master Plan, the Regional Action Plan for the Improvement of Irrigated Crops, the Strategic Environmental Action Plan, etc.). The project supports the evaluation of alternative measures and solutions as proposed by the OMVS.

For example, access to energy services is a priority for economic development in the basin, especially in rural areas. Access to energy for small and medium enterprises is difficult, inconsistent and often expensive, but at the same time the valorization of crop residues can have strategic worth. Hence, the e-Nexus multi-objective optimization module is being developed specifically to assess the impact of alternative agricultural land and water allocation in the basin, in collaboration with technical and scientific staff and local experts and other stakeholders. The optimization technique offers quantitative insights into the impact of strategic questions, notably regional satisfaction of resources demand, greater or lesser continuity with previous management rules, and the maximization of energy or food production. The comparative analysis of strategies allows for quick identification of small management differences that will bring benefits without requiring major changes, or the maximum achievable improvements, and helps to detect the main issues with current management rules.

The e-Nexus tool has also been applied in the Mekrou, a tributary of the Niger. The Mekrou basin, which is shared by Benin, Burkina Faso and Niger, is characterized by large land areas dedicated to food production and inadequate water infrastructure. Rural development and the enhancement of agriculture are crucial to alleviate poverty in the basin and also, in turn, to reduce migration. The Mekrou project[167] (2017), which builds on a Cooperation Framework Agreement signed by the riparian countries in 2015,[168] is designed to feed political dialogues with scientific and technical evidence.

With the objective of feeding the political dialogues with scientific and technical evidences, the technical stakeholders of the Mekrou river – comprising local research institutes, and national and regional technical services, including AGRHYMET, the African Centre of Meteorological Application for Development (ACMAD) and the Niger Basin Authority (NBA), coordinated by the JRC – developed and applied the innovative e-Nexus Decision Support System tool[169] to simulate development scenarios as discussed and proposed by policy and decision-makers. This tool is available for use by the NBA and scientific and technical institutions involved in the project. The tool is also installed and operational in AGRHYMET in line with their regional mandate of providing technical support and capacity development to the governments of the Economic Community of West African States (CEDEAO).

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166 Co-funded by the EU and the Italian Agency for Development Cooperation (AICS) and implemented by the Joint Research Centre (JRC) of the European Commission (EC) and the AICS in collaboration with the Senegal river basin organization OMVS and the Directorate-General of International Partnership (DG INTPA) of the EC.

167 Funded by the EU and implemented by the JRC and the Global Water Partnership (GWP) through an Administrative Arrangement with DG DEVCO.

168 GWP South Africa, "Mékrou Basin: the three countries sign the cooperation framework" (2016). Available at: www.gwp.org/en/GWP-West-Africa/WE-ACT/themes2/PROJET-MEKROU/Activites--Actualites/Mekrou-Basin-the-three-countries-sign-the-cooperation-framework.

169 Angel Udiasand others, :A decision support tool to enhance agricultural growth in the Mékrou river basin (West Africa)" (*Comput. Electron. Agric.*, 2018) vol. 154, pp. 467–481. doi:10.1016/J.COMPAG.2018.09.037.

Sava: A river basin organization facilitating nexus dialogues across countries

A nexus assessment of the Sava basin shared by Bosnia and Herzegovina, Croatia, Montenegro, Serbia and Slovenia (and for a very small part, Albania),[170] carried out under the Water Convention with the institutional support of the International Sava River Basin Commission (ISRBC) and the technical support of the JRC and KTH Royal Institute of Technology, contributed to the integration of water policy with other policies and further dialogue with key stakeholders in the sectors.

The assessment illustrated the value and benefits of transboundary cooperation for balancing increasing energy generation, achieving ambitious regional climate and energy policy targets, and maintaining the present good status of shared waters. Key recommendations included the systematic use of policy instruments, more reliable data and information gathering, and the coordination of investments to promote multiple and flexible use of infrastructure.

The Framework Agreement on the Sava River Basin (FASRB) and the ISRBC provide a legal and institutional framework for cooperation at international and inter-sectoral scales. Crucially, the ISRBC supports the establishment of joint objectives for the countries concerned and serves as a forum where different interests (navigation, water management, flood, drought and accidental pollution management, development issues such as recreation and tourism, industry, agriculture or hydropower) are represented and issues of common concern can be discussed. As such, it functions as a valuable space for the coordination of the different sectoral development plans and the establishment of integrated systems (e.g. information and data exchange, flood forecasting and warning systems).

While the involvement of the energy and agricultural sectors in basin-level coordination is still at an early stage, the Strategy for Implementation of the FASRB envisages further integration of water policies with other sector policies. As such, the nexus assessment participatory process has helped to broaden stakeholder involvement in the framework of the ISRBC.

[170] UNECE, "Reconciling resource uses in transboundary basins: assessment of the water-food-energy-ecosystems nexus in the Sava River Basin" (UNECE, Geneva, 2017). Available at: https://unece.org/environment-policy/publications/reconciling-resource-uses-transboundary-basins-assessment-water-3.

Mekong: Positive and negative impacts of basin development pathways

The nexus assessment approach has been used in the Mekong river basin over many years. Its most recent application, as part of the design and implementation of the study "Sustainable Development and Management of the Mekong River Basin", explored the impacts of a $5 million hydropower project over a five-year period up to 2018. The study examined all water-related sectors of the Mekong – irrigation, hydropower, navigation, flood, drought and water supply – and assessed their possible development impacts across a range of indicators in the environmental, social, economic and climate spheres. The results found synergies as well as trade-offs in the national plans of the riparian states.

The findings of the study as well as those of other studies were discussed extensively and provided inputs to the Mekong Basin Development Strategy 2021–2030,[171] which has been endorsed by the Mekong governments. The updated strategy takes into account current developments in the various sectors, illustrates the implications of development options (including, notably, energy and agriculture), and suggests possible nexus solutions. The Mekong River Commission (MRC) has taken an active role alongside other regional organizations in working to identify such solutions, both at a technical and policy level, through enhanced regional integration. For example, Priority 3 of the above Strategy, entitled "Enhance optimal and sustainable development by increasing regional benefits and decreasing regional costs", incorporates activities on "proactive regional planning" which aim to generate basin-wide and joint investment projects with multiple purposes (energy, flood, drought, navigation). In this context, the Strategy aims to "assess alternative cost-effective regional energy/water system integration options (e.g. floating solar with hydropower, seasonal storage, etc.) within the context of broader energy sector plans including solar and wind and as informed by comprehensive regional options assessment(s) by countries and other regional actors (ASEAN, GMS, etc)."[172] It should be noted that innovative technologies such as floating solar already exist in the different riparian states, and have been applied in Thailand, and considered in Cambodia and Lao PDR. Basin coordination would enable upscaling of these approaches in a sustainable manner.

Despite this effort, challenges with implementing this cross-sectoral strategy still persist. On the one hand, there is some resistance to new ideas; on the other, the water and environment sector sometimes lack the necessary influence (compared to the energy and industry sectors, etc.) to affect political economy decisions at a high level. Here, strategic support for the MRC and riparian countries from trusted partners can make a difference in contributing to the successful implementation of the Strategy.

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171 Mekong River Commission, The Integrated Water Resources Management–Based Basin. Development Strategy for the Lower Mekong Basin 2021–2030 and the MRC Strategic Plan 2021–2025 (MRC Secretariat, Vientiane, Laos, 2021).

172 Ibid.

Niger river basin: RBO applying a nexus criteria to development projects

Resource security in the Niger River Basin – shared between Cameroon, Chad, Côte d'Ivoire, Burkina Faso, Benin, Guinea, Mali, Niger and Nigeria – represents a concern for the riparian states. Of the 160 million people living in the basin area, 60 per cent do not have access to safe water and only 20 per cent have access to energy. Some 70 per cent of agriculture is rainfed and only 20 per cent of the estimated hydroelectric potential is exploited. On this basis, the Shared Vision of the Niger Basin Authority (NBA), which has been ratified by the heads of state, aims to apply integrated management of water resources and associated ecosystems in order to improve living conditions and prosperity by 2025.

A major challenge for the NBA and its nine member states is the overall coherence of basin development and the management of infrastructures.[173] Planned projects include very large multipurpose dams (> 1 billion m^3) to enable irrigation, and provide hydropower and low flow support. There are six existing dams in Cameroon, Mali and Nigeria, one presently under construction in Niger, and two planned in Guinea and Mali. Even if each project proposal, taken by itself, is multi-purpose in nature, it is unclear how they relate to each other or whether one proposal might compromise another.

To fill this gap, the NBA is integrating the nexus approach into its Operational Plan (OP) and investment portfolio. This is being done through participative mainstreaming covering 350 projects and 250 climate actions – encompassing green and grey infrastructure on water and land and ecosystem-based adaptation, including in humid zones and forest areas – multi-sectoral planning, standards and indicators, and fundraising. These nexus criteria for the selection of projects are applied at three different levels:

- conception of projects in the national context (inter-ministerial consultations);
- project implementation with local communities; and
- pre-feasibility studies undertaken to attract financial support.

The entire OP has a total cost of $7.2 billion for the period 2016–2024.[174]

The NBA faces challenges related to the complex geopolitical and economic context in the basin, and poorly applied water regulation in the riparian states due to inadequate institutional arrangements and mechanisms and lack of institutional capacity. As a remedy, a Permanent Technical Committee within the NBA could be established to overview the coordination of water management and regulations.

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[173] GIZ, *Niger River Basin Nexus Profile* (GIZ, Bonn, Germany, 2018). Available at: https://uploads.water-energy-food.org/legacy/nexus_profile_niger_basin__english.pdf.

[174] Presentation by Abdou Guero on 22–23 October 2020 at the sixth meeting of the Task Force on Nexus under the Water Convention (UNECE, 22–23 October 2021).

Danube: Sustainable agriculture to improve transboundary water quality

Sustainable nutrient management and drought management are highly challenging issues in agriculture in the Danube River Basin (DRB) Agriculture is an important component of the economy in many Danube countries, since the geographical and climatic conditions in large parts of the basin are favourable for crops. However, despite substantial subsidies from the EU and national governments, the agriculture sector also faces major socio-economic challenges. In many regions the intensity of production is low due to less favourable economic conditions, and in areas where land productivity is low, farmers often face difficulties, as agriculture in these regions may not be competitive at all. In many Danube countries, a significant number of small farms operate on just a few hectares and are highly dependent on EU or national subsidies. Such subsistence farms have only a limited capacity to comply with strict and ambitious cultivation provisions.

At the same time, water-related environmental concerns are strongly related to agriculture. Nutrient pressure from agricultural diffuse sources could increase and affect the status of surface waters, groundwater and the Black Sea. Additionally, in the context of climate change, the duration and magnitude of drought events are forecast to increase in summer months. Such extreme weather conditions could trigger serious water scarcity. The International Commission for the Protection of the Danube River (ICPDR), as the coordinating body for transboundary water management in the DRB, is committed to assisting Danube countries to address these challenges.

In line with the EU initiative of aligning water and agricultural policies under the new Common Agricultural Policy (CAP), the European Green Deal and its relevant strategies and ambitions, the ICPDR launched a dialogue with the agricultural sector aimed at the development of a guidance document on sustainable agriculture. This document will offer Danube countries support for the preparation and implementation of national agro-environmental policies, CAP Strategic Plans and relevant strategies of River Basin Management Plans. It will provide a consistent policy framework with a set of recommended instruments and tools to facilitate national water and agricultural decision-making, identify common goals, set up tailor-made policies, and implement joint actions and cost-effective measures.

Lake Titicaca: Valuing shared ecosystems with local communities

Located between Bolivia and Peru, Lake Titicaca is a large freshwater body, transboundary ecosystem and Ramsar site, considered by the riparian states to be an indivisible ecological unit that is critical for the survival of high Andean communities. The lake is facing serious pressures from environmental degradation, climate change and water demands, notably from the Mauri river where part of the water is diverted for irrigation and domestic use, affecting some local communities who rely on water for domestic use and agriculture, and on the health of the ecosystem. As the level of the lake recedes due to a shortening of the rainy season and receding glaciers, water security and worsening water quality, due to wastewater discharged directly into the lake, have become a threat to local communities.[175]

The two countries have established the Authority of Lake Titicaca (ALT) with a mandate to improve implementation of IWRM in the lake. The ALT supports projects related to water quality assessment, fish farming and water treatment for domestic uses.[176] This approach could support a broader nexus dialogue at the policy level between the two countries aimed at the design and implementation of investments with shared benefits in the basin. However, limited coordination between sectors and within the countries means that basin investments are conducted only for specific benefit outcomes without pondering the trade-offs with other water uses. A multiple-benefit vision would improve the quality of decision-making when it comes to water investments, however a certain disconnection remains due to the way in which institutions and policies are designed, and a lack of effective dialogue spaces and institutional capacities. For this reason, both countries have undertaken an effort to modernize the ALT to respond to current challenges.

Conversely, the two countries can rely on an increasingly active community concerned with the environmental protection of the basin and its sustainable development, as the lake ecosystem naturally connects communities across borders. The IUCN's BRIDGE initiative focuses on empowering local communities to protect the lake's water and ecosystem, and places women and environment at the centre. Women play a key, although often unrecognized, role in water gathering, use, administration and sharing. "Mujeres Unidas en Defensa del Agua" evolved as a network with the potential to catalyse grass-roots sustainable water solutions that arise from Indigenous knowledge[177] and new water monitoring and communications technologies that are adapted to new challenges. These enhanced capacities have engendered a new understanding of the causes of pollution in the lake and the actions that can be taken to address them, including municipal wastewater treatment plants and solid waste management solutions, the operationalization of which remains the greatest challenge to improving water quality both in the rivers and Lake Titicaca itself. However, new monitoring plans and clean-up campaigns have empowered women and local communities to demand action.

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175 IUCN, "Lake Titicaca: empowering women and improving water governance" (webpage, n.d.). Available at: https://digital.iucn.org/water/lake-titicaca.

176 Autoridad Lago Titicaca, On fishery (2020) and potable water treatment (2018). (webpage). Available at: www.alt-perubolivia.org.

177 See for instance: IUCN, "Launch of Stories from Lake Titikaka: a collection of stories, myths and legends" (webpage, 15 February 2021). Available at: www.iucn.org/news/south-america/202102/launch-stories-lake-titikaka-a-collection-stories-myths-and-legends.

The case of Lake Titicaca is an illustrative example where transboundary cooperation is happening at two levels: inter-governmental (institutional) and local (civil society). Some women leaders are acting now as counsellors in their respective municipalities, and will work with ALT at the level of local governments, reinforcing each other in their objective of restoring and protecting the lake.

7. FINDINGS FROM THE STUDY

The findings from this stocktaking exercise are largely illustrative of the experience of water institutions concerned with transboundary issues, which responds to the need of taking stock of experience that is relevant for the main audience of this publication. However, this experience does not fully reflect the potential of initiatives from other sectors (e.g. technical solutions for water and energy efficiency in industry, nexus solutions in urban settings, small-scale investments in sustainable agriculture and forestry, etc.) that can be applied and upscaled in transboundary basins. More far-reaching intersectoral actions may be possible at local and national levels, and may also be extended in terms of impact and shared experience at the transboundary level.

At the regional level, especially in relation to regional energy planning, there may be opportunities for basin organizations to provide a forum for discussing the water needs of planned developments and potential impacts on water resource, or to bring a common voice to those discussions. Solutions within economic sectors and other resource management domains would certainly help to provide a more complete picture of the possibilities.

There are clear ways forward to ensure further uptake and upscaling of nexus solutions and investments in transboundary basins. These include (i) basin-level action plans (e.g. the Strategic Action Plan of the Drin, which includes energy, forestry and agriculture-related actions); (ii) coordinated strategies and investment plans (e.g. the Mekong strategy which promotes the upscale of non-hydro renewables, or the NBA approach which is used to evaluate/revise projects using nexus criteria), and (iii) specific projects (e.g. the Itaipu hydropower plant, which also provides for the protection and amelioration of land ecosystems surrounding the reservoir). In general, as the study shows, cross-cutting regional strategies agreed by multiple governments, river basin plans developed jointly by riparian states and regionally coordinated financial support from financial institutions can all be important vehicles for the joint prioritization and implementation of coordinated nexus solutions and investments.

Emerging trends from the analysis

An examination of the experiences gathered through the survey and literature shows that where the nexus concept is understood, or where constraints on its adoption are minor, such an approach is useful to tackle multisectoral problems. It should be noted, however, that intersectoral actions of relevance are not necessarily recognized as "nexus solutions" and indeed the understanding of what constitutes such a solution varies greatly. Some solutions submitted through the survey may retain a conservation focus within a basin but still aspire for greater involvement of and action from the side of economic sectors.

The typical problems tackled by means of a nexus approach in the case studies analysed relate more often to water quality and environment rather than to water quantity (availability, variability), even though "anthropogenic change in hydrology" is the most common root cause reported. However, an examination of experiences beyond the survey show strong support for the application of a nexus approach to water investment planning from the side of regional organizations (notably RBOs) and financing institutions, with a view to solving water quantity-related problems. Clearly, the perspective taken in this study stems from the water and environment sectors, and to some extent energy (notably hydropower),[178] although more integrated solutions and investments also come from the energy and agricultural sectors, indicating a common interest in cross-sectoral coordination to achieve the SDGs, particularly in relation to climate action.[179]

In the basins considered, problems ultimately arise from anthropogenic causes related to water and land management, with climate change in some cases adding significant pressure. Institutions often lack the resources and capacity to tackle these complex issues, ensure appropriate cross-sectoral coordination, collect adequate data and share information, and ultimately attract and channel the necessary investments. Understanding of how the financing of nexus/multisectoral projects works in practice within water institutions may be limited – and also depends on the centralization/decentralization of these institutions, and whether they are structured to work across sectors and/or at

[178] It should be noted that several important energy and industry-related intersectoral issues did not emerge in this study (e.g. mining of fossil fuels, biofuels and non-renewable deployment).

[179] Nexus initiatives of global relevance include those of the International Energy Agency (www.iea.org/topics/energy-and-water), the International Renewable Energy Agency (www.irena.org/publications/2015/Jan/Renewable-Energy-in-the-Water-Energy--Food-Nexus) and the Food and Agriculture Organization of the UN (www.fao.org/policy-support/tools-and-publications/resources-details/en/c/421718).

different geographic scales – and indeed attention to multisectoral solutions is rather recent. This lack of knowledge risks becoming a major capacity gap that could prevent such institutions from identifying (or coordinating) bankable cross-sectoral projects. Mandates might also limit such opportunities, which raises the important question of what kind of partnerships and modalities would best support the implementation of cross-sectoral projects.

Success factors and the added value of nexus solutions

Examples of cross-sectoral cooperation with transboundary benefits emerge from all regions. These "nexus solutions" are operationalized through international cooperation, governance, economic and policy instruments, and infrastructure and innovation.

Among the highest-ranking enabling factors in the implementation of these solutions are stronger transboundary cooperation, shared data and information, compromise and synergies, innovative infrastructure operating rules, and increased awareness of options and benefits for cross-sector, transboundary trade-offs (although there are many others). These enabling factors depend largely on the institutions themselves, as they are best positioned to create an enabling environment for nexus solutions. While not all case studies profit from the participation of an institutional framework of transboundary cooperation, where they exist, RBOs can play a key role as facilitators or even catalysers of nexus solutions and investments.

Interestingly, many of the challenges to implementation that emerge from the study also relate to institutions. Notable among these are politics, data and information shortcomings, inadequate institutions, financial constraints, persistent policy/sector silos, and limited technical capacity, time frames and options for benefit-sharing.

The respondents to the survey perceived the added value of a nexus approach in terms of more effective management of basin issues on the part of institutions, rather than the delivery of benefits related to resource and regional security and economic efficiency. This perception shows that the economic and non-economic benefits of nexus solutions are still unclear, which makes it difficult to catalyse the resources necessary to operationalize solutions and transform them into concrete projects. In transboundary basins, where investments are generally deemed to be high risk in nature (compared to national investments), a lack of clarity regarding the benefits of cooperation further reduces the prospects of funding opportunities.[180] More needs to be done, therefore, to clarify these benefits by sharing knowledge and experience.[181]

Financing nexus solutions and investments

At present, most of the financial resources used to implement nexus solutions come from the state (including donor financing), despite broad recognition that the nexus approach opens up clear opportunities for more private and blended finance though "green" investments in agriculture, energy, tourism and so on. The delivery pathway is also important. Based on the study, for example, there seems to be a correlation between infrastructural measures and adaptable programmatic financing, where funds are allocated to a programme (e.g. modernization of irrigations systems in a river basin) without connection to a specific project.

Water- and environment-related problems need to be tackled effectively across sectors, an endeavour that may require significant financial resources. In the absence of effective cooperation, there is a strong chance that economic sectors will put in place their own solutions to solve immediate problems without building a common vision of sustainable basin development. However, this approach represents a missed opportunity for water management and environment protection, which could gain concrete benefits from these interventions. By designing solutions and planning investments together across sectors, water institutions at the national and basin level can catalyse the implementation of well-integrated solutions that are both environmentally sustainable and bankable.

The study shows that financing institutions are increasingly concerned with the coherence of multiple projects in transboundary basins. There are examples of such institutions providing technical support to countries to prioritize or review projects, taking into account their cross-sectoral and transboundary impact. Coordination, not just in regard to investment plans but also in terms of upstream, macro-level, integrated planning, data and monitoring, Environmental Impact Assessments and Strategic Impact Environmental Assessment processes, or other social and

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[180] Blue Peace Voices, *Is Finance the Final Frontier to Ensure Long-Term Benefits from Transboundary Cooperation?* Available at: www.thebluepeace.org/blue-peace-voices-final-frontier.

[181] IUCN, "Increasing returns on investment opportunities by applying a nexus approach: Best practice nexus case studies" (Belgrade, IUCN, 2019).

environmental safeguards frameworks, is particularly important to de-risk investments of regional importance. Ultimately, the political will to cooperate and coordinate, with a view to ensuring long-term sustainability (economic, environmental and social), will encourage investors to engage, including private entities who need structured financing schemes and can help close financial gaps.

Regional experiences

Regional nexus dialogues focusing on transboundary water management have been organized in several regions of the world across Africa, Asia, Europe and the Americas. In general, these dialogues are informed by technical studies that address cross-sectoral impacts, the implications of development and climate change. However, the central focus of all these dialogues is the operationalization of nexus solutions and investments. The latest nexus assessments under the Water Convention supported the joint identification of coordinated actions (e.g. the "package of solutions" in the NWSAS) and the identification of projects of transboundary benefits (e.g. the Drin and the Drina in South-East Europe). The Nexus Regional Dialogues Programme, funded by the EU and implemented by the GIZ (a global programme that implemented dialogues in MENA, Central Asia, the LAC, Southern Africa and the Niger River Basin), is now focusing on the mobilization of finance for nexus projects. Across different regions, there are examples of international finance institutions taking the lead on the analysis of nexus dynamics to support countries in the identification of needs and/or project prioritization (e.g. the Sava-Drina Corridor) and proposing sustainable financing schemes that involve nexus sectors (e.g. the Trifinio water fund).

The role of river basin organizations

Depending on their specific mandate and influence, RBOs can play an important role in coordinating, catalysing or participating in nexus dialogues. Crucially, by coordinating with other regional organizations (e.g. economic commissions, organizations for energy integration, etc.), RBOs can facilitate the cross-sectoral dialogue necessary to develop water infrastructure (grey and green) in shared basins. Accordingly, their contribution can be vital to the development of master plans that are "nexus proofed". Examples illustrate how they can provide a platform for nexus dialogues (the ISRBC), a space to evaluate projects and their overall coherence (the MRC or the NBA), a source of common guidelines for sustainability in sectoral policies that have implications for shared waters (e.g. ICPDR on agricultural practices, as well as sustainable hydropower), or support for large-scale, integrated analysis of natural resource development (ACTO). However, much depends on their institutional structure and mandate, and the availability of resources and capacity, as well as the willingness of countries to use these platforms to discuss strategic policies and investment plans.

Possible use of the findings on nexus solutions and investments

The outcomes of the stocktaking exercise establish an important knowledge base that could benefit from further improvement. In fact, some important questions that would make the stocktaking exercise a useful resource for countries and basins, still require further clarity:

- Who should (or who can) develop nexus solutions and how? What are the costs and benefits associated with them (and, in particular, their economic added value)?
- What types of institutional frameworks (particularly in transboundary basins) are needed to support the implementation of nexus solutions and to de-risk investments?
- What financing sources are available to support multisectoral programmes or projects of transboundary relevance?

Regional planning and strategic documents

The strategy of the GEF-IW recognizes trade-offs in the water-food-energy-ecosystem security nexus as an important challenge crucial to the implementation of Strategic Action Programmes (SAPs). Identifying nexus investments, with a view to reinforcing strategic action programmes and broadening partnerships for joint action with other sectors and investments, can consolidate and synergize efforts for greater impact. Regional nexus dialogues supported by various organizations (e.g. the EC, the GIZ, the GWP and the OECD) could also potentially benefit from building on this synthesis, by considering possible applications of the framework for nexus solutions and investments developed for the analysis described in the present report.

The survey

Looking beyond this synthesis, a broader and more diverse stocktaking of nexus solutions and investments, concretely expanding the survey to include more basins and a wider range of stakeholders, would help to draw conclusions regarding the types of solutions and cross-sectoral cooperation that have most effectively tackled basin issues. The greatest benefits lie in the extension of outreach in the following directions:

- *Beyond the basin scale.* Unlike IWRM, the nexus approach is not scale-specific, and looking "beyond the basin" can help capture relevant nexus solutions that indirectly provide transboundary benefits.
- *More towards water-using economic sectors.* Despite its "nexus intention", the study largely focused on watershed rather than "cross-sectoral" issues. Although the choice to derive the most typical problems from the experience through transboundary diagnostic analyses ensured that the solutions were relevant for institutions concerned with water management, it also meant that important issues related to other sectors were only indirectly considered (among "root causes" and "factors of success in the implementation").
- *Beyond the group of stakeholders concerned with institutional support.* The findings so far indicate a surprising lack of case studies related to either green or grey infrastructure.

Further development and use of the survey would help to capture more details about trade-offs, synergies and compromise, and about the knowledge, attitude and perception of stakeholders with respect to the water-food-energy-ecosystem nexus, especially among development partners, national governments and RBOs. The survey could be further used, for example, in different regions to analyse in more detail how cross-sectoral solutions and investments help to address issues in transboundary basins. This approach could support identification of specific opportunities and the operationalization of nexus solutions in the framework of transboundary or regional intersectoral strategies. In some of the regions where nexus assessments have been carried out, such documents are being developed, in some cases complementing strategic action programmes (e.g. GEF-IW).

8. CONCLUSIONS

As this report shows, the potential value of coordination and integrated planning across sectors is receiving increasing recognition; however, the obstacles to practical achievement can be significant.

The case studies analysed and presented in this report are drawn from a survey and a literature review, with further input from expert consultations and a review of regional nexus dialogues. The data from the survey and literature were subject to a range of quantitative and qualitative analyses to identify common features and trends in terms of problems and solutions, financing sources and schemes, obstacles to implementation and enabling factors, as well as perceived added value and benefits. Although the survey was intended to reach a broad variety of respondents, including from economic sectors, the majority of respondents were stakeholders from the Water Convention, the BRIDGE project networks and GEF-IW projects. Further experiences collected from expert consultations and regional nexus dialogues were considered only if they were of relevance (at least potentially) for transboundary water management.

The insights from the stocktaking exercise may help governmental authorities and other actors to better understand the potential of the nexus approach and to take steps where intersectoral solutions have been identified but operationalization has proven challenging, or in cases where transboundary basin issues can be addressed through engagement by water authorities with economic sectors.

In this regard, determining the root causes of the problems in transboundary basins is key, and nexus dialogues can take policymakers a step further by helping them to act upon them. Policies may need to be adjusted and regulation may need to be revised, which requires time and effort, but such processes are necessary to ensure coherence towards sustainable development. Some beneficial upgrading of capacities can be achieved through learning by doing, and exchanging and sharing knowledge and experience, with a view to overcoming sectoral challenges. In transboundary contexts, institutional frameworks and legal agreements have an important role to play in terms of coordination and cooperation on nexus solutions and investments with shared benefits.

Clearly, current levels of investment in water are insufficient; however, unexplored or underexplored opportunities may emerge from coordination and partnering across sectors and also across borders. Political will is crucial to benefit from such cross-sectoral financing opportunities, and high-level policymakers as well as non-line ministries (e.g. finance and economy) will need to be convinced. A review of existing programming frameworks with a view to their improvement, including through jointly defined priorities, is possible and timely. The COVID-19 pandemic and the recovery process – with associated changes in the use of natural resources and economic outlooks, climate action commitments, and objectives related to sustainable development and the green and circular economy – have already prompted reviews of programming, and the space for transboundary and multisectoral actions and investments could be enlarged even further. In this context, international financing institutions are already exploring innovative approaches to coherent multi-country lending.

Water management and environment policymakers

The application of a nexus approach creates opportunities for natural resource management in transboundary basins and the coordination of national policies to design and implement nexus solutions and investments using strategic documents (e.g. through SAPs). This approach could help tackle environmental concerns such as pollution, climate change and biodiversity loss in a more effective manner that involves all concerned stakeholders. However, major obstacles to implementation include capacity and financial resource gaps, and the absence of political will to engage in cooperation. Regional experiences show that international organizations and financing institutions are stepping up technical support, capacity-building activities, the facilitation of political dialogue, and the identification and nexus proofing of projects.

While the nexus approach opens up opportunities to leverage finance for investments in water and the environment, greater clarity is required to ascertain where related needs and interests overlap or conflict with those of other sectors, and to identify common ground for scoping proposals. Efforts are also required to improve the bankability of projects and coherence within investment portfolios (at national and international levels). Climate action (e.g. NDCs, NAPs) as well as activities aimed at environmental protection demand close intersectoral coordination and can benefit from the prospect of co-financing for multi-sectoral projects or sectoral projects within a coherent programme across both sectors and countries.

Energy and agriculture policymakers

The energy and agriculture sectors are the largest users of water and accordingly need to take a proactive role in proposing solutions and investments that integrate the needs of the water sector and the environment. All forms of energy generation directly or indirectly require water and land, and agriculture is the biggest water user of all sectors at the global level. Efforts to ensure the effective management of risks – which may relate to competing water and land use among other sectors – can benefit from (strategy and policy) consultations and coordination with water and environment authorities at an early stage. This approach helps to avoid delays and controversy at later stages.

Innovative energy and agriculture/forestry solutions have significant potential to generate cross-sectoral benefits. However, such solutions are designed at the sub-national or national level, implying that their potential contribution to tackle the most pressing issues in transboundary basins or to generate transboundary benefits often remains unclear to the actors concerned. River basin organizations (RBOs) and regional cooperation frameworks could help coordinate, upscale and exchange experience about such solutions.

Improved cooperation between the energy and agriculture sectors and water management authorities can lead to more, and better, nexus solutions and investments in transboundary basins, by opening up new opportunities for cross-sectoral cooperation across riparian countries (and potentially also stimulating innovative financing approaches and/or co-financing solutions). Even when such cooperation does not provide immediate co-financing opportunities, the generation of efficiency and sustainability solutions during project design can translate into economic benefits over the longer term. Conversely, uncoordinated actions to solve specific problems may fail to address the issues at stake at larger scales (e.g. when water savings generated by the application of water use efficiency measures are lost by the expansion of irrigated land). For this reason, it is crucial that sectoral policies and investment plans are evaluated against their contribution to national and regional objectives in order to increase resource security, peace and stability, and sustainability. In this way, a broader planning scope can enable more optimal placement of measures.

In addition, sectoral strategies are more effective if they take into account development alternatives and related trade-offs, sustainability and transboundary-related issues early on in the process. There are many tools available and RBOs (where they exist) can play a key role in facilitating dialogue with the water and environment sectors.

Finance and economy and other non-line ministries

Water and environment may rank low in the priority of countries compared to energy and agriculture, in spite of the fact that water as a resource and provider of healthy ecosystems is fundamental to all economic activities and social wellbeing. The nexus approach can be helpful to design integrated packages of investments that make the best use economic of the financial resources available to reach multiple sustainable development objectives at the same time, and – by the virtue of their broader scope – may become eligible for more funding sources.

Programmatic funding is an efficient way to mobilize public funding and private financing for infrastructural investments (especially if basket funding modalities are possible), circumventing the hazards cited by both the public and private sectors with respect to financing water sector infrastructure. Furthermore, programmatic financing schemes may be better suited than project specific solutions to deliver multiple benefits from a nexus perspective (reducing trade-offs and leveraging synergies). In transboundary settings in particular – where sectors are interconnected through water – these schemes can allow different sectors to co-design nexus solutions taking into account their cumulative social and environmental impact without being constrained by predefined characteristics (e.g. on siting or type of solution) that might have been decided previously by different sectors in an uncoordinated manner.

Today, public funding (including from donors) constitutes the main source of nexus investments of transboundary value. However, the nexus approach also opens up financing opportunities from the private sector that can be leveraged through public-private partnerships, blended finance solutions, indirect support (e.g. through tax incentives), green/blue bonds and basket funding. Prospects also exist to design innovative schemes (including revenue-based models) that leverage private investments for both infrastructure and institutions. These schemes for multi-sectoral projects can be crucial to access climate funds as well as environmental funds. Thus far, this potential has barely been utilized in transboundary basins where more stakeholders need to be involved. However, political commitment to coordinate such investments could reduce the perceived risk for investors and unlock

new resources. Such engagements by co-riparian countries can reinforce transboundary cooperation, allowing progressively more ambitious joint projects to be negotiated and undertaken.

One of the main barriers to shared investments in transboundary basins is that lending from many public lenders and international financing institutions is dependent on sovereign warranty loans. This means that each country contracts its own loan. Shared investments can be catalysed at the early planning stage by defining investments from a basin perspective; however, the investments remain fragmented depending on each country's interest and financial capacity to absorb public debt. Innovative approaches for joint lending through regional programmes or integration lending windows could provide a better foundation for nexus (as well as sectoral) investments in transboundary basins. Transboundary cooperation agreements and negotiation processes could be used to facilitate the implementation of these approaches, with RBOs playing a crucial coordinating role.

Actors engaged in transboundary water cooperation/conflict prevention

Understanding the interlinkages between water, energy, land/food and environmental resources can open up crucial opportunities to generate cooperation benefits or to reduce tension. Going further, nexus solutions may be of help in building trust and preventing conflict, provided that international water law principles are respected.

Insights into nexus issues and solutions can therefore help devise interventions that reduce pressure on shared water resources by acting on economic sectors that use water or have an impact on water resources. Such actions can reduce existing or potential tensions among co-riparian (or aquifer-sharing) relations.

Trade relations influence how resources are used, how their potential is exploited and how the related benefits are shared. As the production of many important agricultural goods requires land and water endowments, trade can be a strategic means for optimizing the production of water-intensive goods.

The engagement of economic sectors in an intersectoral transboundary dialogue about sustainable development (or other common objectives) in a shared basin improves mutual understanding of problematic issues that affect riparian states at an economic level. This type of dialogue can help uncover unconventional solutions to problems that water management or allocation struggles to solve, because the perspective of investments that benefit all riparian states and multiple sectors can provide the necessary motivation to engage in cooperation and take necessary action.

ANNEX 1. QUESTIONS, DEFINITIONS AND CRITERIA

Table A1. Questions, definitions and criteria

Question	Clarification	Definitions	Criteria
What are the most common problems in transboundary basins?	In the context of this study, the problem must involve the management and/or exploitation of transboundary waters (see Annex 3). There may be a range of root causes (for a full list, see the questionnaire)[182]	Quantitative and/or qualitative phenomena that are transboundary in cause and/or effect. The phenomena can be natural or anthropogenic in nature and could be seasonal.	• The problem must have been encountered in more than one instance, and ideally in more than one location across more than one basin/region. • More than one of the sectors must be involved, either as a causal factor or as a recipient of the consequences.
What are the main categories/ typologies of solutions?	UNECE has stated that it intends to work with the pre-existing "5I" concept, to the extent that it is meaningful. The adaptation of this concept for the Solution Axis of the analytical framework is explained in Annex 4.	For the purpose of this study, a solution is understood as an objective of a particular kind.	Solutions are captured by one of the following "Mezzanine" objective clusters: • international cooperation • governance • economic policy and instruments • infrastructural innovation.
What are the most common trade-offs and synergies across sectors and countries?	Compromise can also be included as a nexus option.	For the purpose of this study: • A *trade-off* means that a preferred objective is traded for another. • A *compromise* is a result which is less than perfect for one or more stakeholders, but is accepted by all involved. • A *synergy* occurs when one intervention covers multi-sector objectives.	For the purpose of this study, a solution must be either a trade-off, a compromise or synergistic in nature.

[182] Questionnaire available at: https://unece.org/environmental-policy/events/6th-meeting-task-force-water-food-energy-ecosystems-nexus.

Question	Clarification	Definitions	Criteria
What benefits arise from cross-sectoral cooperation in transboundary basins and can be used for the purposes of communication and advocacy?	This clearly a fundamental output of the study, but also an interesting question because the benefits as perceived by policymakers and planners may differ from those perceived by water users/water-using sectors. Some of the literature suggests that benefits arise from perceptions of improved security (in a variety of ways). However, in order to influence policymakers and planners, the benefits should be political and economic in nature.	For the purpose of this study, benefits can be defined as follows: • equitable economic growth accruing to multi-sector water management and utilization (this falls within the upper-left quadrant of the UNECE typology for transboundary water cooperation);[183] • reduced political cost of nexus solutions (relevant to the bottom left quadrant); and • increased basin welfare[184] (cross-cutting relevance to upper-left and right quadrants).	For the purpose of this study, a solution must suggest or support a communication or advocacy campaign targeted at policymakers and planners in all water-using or dependent sectors, as well as those in non-line ministers such as ministries of finance or economic development.
What enabling factors exist for the implementation of solutions (notably institutional arrangements and financing frameworks)?	This is also a fundamental output of the study, because enabling factors either reduce the political cost of nexus solutions or increase the available political capital. (The role of public awareness and "sanctioned discourse[185]" may be relevant here.)	For the purpose of this study, an enabling factor is any factor that reduces the political or institutional cost of nexus planning or decision-making.	There is no need for criteria here because any nexus solution will have enabling factors of some sort. Criteria therefore have no utility in terms of filtering irrelevant from relevant solutions.

[183] UNECE, Policy Guidance Note on the Benefits of Transboundary Water Cooperation (United Nations, Geneva, 2015).

[184] Defined here as the ratio of the economic productivity of water to levels of competition for, or conflicts over water. In other words, if economic productivity goes up and competition goes down, basin welfare increases.

[185] Defined here as the "space" within which political decisions are affordable in terms of political capital, and which for obvious reasons is influenced by public awareness, which in turn can be influenced by communications and advocacy campaigns.

ANNEX 2. DEVELOPMENT OF THE PROBLEM AXIS

The elements of the problem axis of the analytical framework were established using the following methodology.

First, a list of 147 problems were derived from a list of 24 Transboundary Diagnostic Analyses (TDAs).[186] The majority of these problems were encountered in multiple TDAs. The problems were then classified according to the following categories:

- cause
- effect
- both (e.g. changing rainfall patterns could cause water scarcity, while water scarcity could be an effect of poor water resources management and wastage)
- unclear (e.g. variable hydrologic regimes may be anthropogenic or natural)
- cross-cutting (i.e. the problem could be the cause or result of a wide range of problems).

Table A2 presents the categorization of specific transboundary basin problems.

The problems categorized as "both", "unclear" or "cross-cutting" were discarded because a closer examination confirmed that the issues at stake were adequately captured by other problems. Finally, the remaining problems were consolidated into 13 causes and 10 effects with respect to water quantity, quality and environment (see Table A3).

Table A2. Categorization of GEF/TDA problems

TDA		Problem	Category
River or basin	Year		
Amazon	2015	Water pollution	Effect
		Deforestation	Cause
		Loss of biodiversity	Effect
		Extreme hydroclimatic events	Cause
		Erosion, and sediment transport and sedimentation	Effect
		Changes in soil use	Cause
		Loss of glaciers	Cause
		Large infrastructure projects	Cause
		Limited Integrated Water Resources Management	Cause
Bermejo	2000	Soil degradation, intense erosion and desertification processes	Cause
		Water scarcity and availability restrictions	Both
		Degradation of water quality	Effect
		Destruction of habitat, loss of biodiversity and deterioration of biotic resources	Both
		Conflicts from flooding and other natural disasters	Cause
		Deteriorating human living conditions and loss of cultural resources	Cross-cutting

[186] The list was provided by the GEF secretariat. Marine examples of TDAs have been excluded for the purposes of the study.

TDA		Problem	Category
River or basin	Year		
Danube	2006	Nutrient pollution	Cause
		Organic pollution	Cause
		Pollution from hazardous substances	Cause
		Hydro-morphological alterations	Effect
Dinaric Karst (aquifer)	2013	Anthropogenic pollution	Cause
		Possible flow reduction due to a hydropower dam	Cause
		Inadequate data and information	Cause
		Agricultural and sanitation waste pollution	Cause
		Industrial pollution	Cause
		Wastewater and industrial pollution	Cause
		Inequitable allocation of water	Cause
		Lack of regulation	Cause
Dnipro	2003	Chemical pollution	Cause
		Loss/modification of ecosystems or ecotones, and reduced viability of biological resources due to contamination and disease	Effect
		Modification of the hydrological regime of surface waters	Cause
		Eutrophication	Effect
		Flooding events and elevated groundwater levels	Unclear
		Pollution by radionuclides	Cause
Drin	2016–2018	Deterioration of water quality	Effect
		Variability of hydrological regime	Unclear
		Biodiversity degradation	Effect
		Sediment transport	Effect
Guarani (aquifer)	2007	Guarani Aquifer System (GAS) pollution problems: wells and aquifer	Cause
		Quantitative problems arising from intensive over-exploitation; decline in GAS water availability	Effect
		Macro strategies: challenges to the sustainable management of the GAS	Cause
Lulumenden (aquifer)	2007	Change in available resources	Effect
		Degradation of water quality	Effect
		Climate variability	Cause
Kura	2013	Variation and reduction in hydrological flows	Unclear
		Deterioration of water quality	Effect
		Ecosystem degradation	Effect
		Flooding	Effect
Lake Baikal	2013	Degradation of aquatic and terrestrial habitats	Effect
		Hydrological regime changes	Effect
		Decline of water quality	Effect
		Unsustainable fisheries and wildlife exploitation	Cause
		Biological invasions	Effect

TDA		Problem	Category
River or basin	Year		
Lake Chad	2007	Variability of hydrological regime and freshwater availability	Unclear
		Water pollution	Effect
		Decreased viability of biological resources	Effect
		Loss of biodiversity	Effect
		Changes and variability in hydrological regime and freshwater availability	Unclear
		Water pollution	Effect
		Invasive species	Effect
		Variability in hydrological and hydrogeological regimes	Unclear
	2018	Biodiversity degradation	Effect
		Sedimentation	Effect
		Climate variability and change	Unclear
Lake Peipsi	2005	Eutrophication of Lake Peipsi (including riverine loads)	Effect
		Fishery management	Cause
		Groundwater pollution and water distribution in the Narva River region	Effect
		Mining pollution from oil-shale activities	Cause
Lake Shkodra/Skadar	2006	Pollution (industrial, municipal, solid and liquid waste)	Cause
		Hunting and fishing	Cause
		Lakeshore development	Cause
		Water management measures	Cause
Lake Tanganyika	1999	Unsustainable fisheries	Effect
		Increasing pollution	Cause
		Excessive sedimentation	Effect
		Habitat destruction	Effect
Lake Victoria	2006	Land use and land degradation	Cause
		Water quality and pollution	Effect
		Water quantity and water balance	Effect
		Fisheries decline and biodiversity	Effect
Niger	2009	Land degradation	Cause
		Water resource degradation	Effect
		Loss of biodiversity	Effect
		Invasive species of aquatic plants	Effect
Nubian (aquifer)	2010	Declining water levels	Effect
		Water quality deterioration	Effect
		Changes in groundwater regime	Effect
		Damage or loss to ecosystems and biodiversity	Effect
		Climate change	Cause

TDA		Problem	Category
River or basin	Year		
Okavanga-Cubango	2011	Variation and reduction of hydrological flow	Unclear
		Changes in sediment dynamics	Both
		Changes in water quality	Effect
		Changes in the abundance and distribution of biota	Effect
Orange-Senqu	2008	Stress on surface and groundwater resources	Effect
		Altered water flow regime	Effect
		Deteriorating water quality	Effect
		Land degradation	Cause
		Spread of alien invasive plants and animals	Effect
Pantanal	2003	Critical issues associated with human presence (water pollution, soil degradation, loss of biodiversity)	Cause
		Critical issues associated with the hydrological flow of the system (critical events, emerging water use conflicts, economic and social losses)	Effect
		Critical issues associated with the socio-political organization (political-institutional fragility and lack of implementation of water resources management instruments)	Cause
Prespa	2009	Nutrient pollution	Effect
		Declining fish stocks	Effect
		Loss of water level in Lake Macro Prespa	Effect
		Sediment transport	Effect
		Deforestation and changes in native forests	Cause
		Organic pollution	Cause
		Hazardous substance pollution	Cause
Rio de la Plata	2010–2016	Extreme hydrological events linked to climate variability and change	Cause
		Water quality degradation	Effect
		Sedimentation of waterways and bodies of water in the basin	Effect
		Disruption and loss of biodiversity	Effect
		Unsustainable use of fishery resources	Cause
		Unsustainable use of aquifers in critical areas	Cause
		Water use conflicts and the environmental impact of irrigated crops	Effect
		Lack of disaster contingency plans	Cause
		Poor water health and the deterioration of environmental sanitation	Effect
San Juan	Date Unknown	Accelerating degradation of transboundary ecosystems	Effect
		Overexploitation of valuable natural resources	Cause
		Soil degradation and increasing sedimentation	Both
		Pollution of water bodies	Effect
		High vulnerability to natural hazards	Cross-cutting

TDA		Problem	Category
River or basin	Year		
Senegal	2007	Surface water availability problems	Effect
		Groundwater availability problems	Effect
		Water quality: pollution/siltation	Effect
		Water quality: pollution/mining operations	Effect
		Change in estuarine hydrodynamics	Effect
		Land degradation	Cause
		Degradation of fish fauna	Effect
		Wetlands degradation	Effect
		Invasive species	Effect
		Waterborne diseases	Effect
Volta	2002	Land degradation	Cause
	Preliminary TDA	Water scarcity	Unclear
		Loss of biodiversity	Effect
		Flooding	Effect
		Water-borne diseases	Effect
		Growth of aquatic weeds	Effect
		Coastal erosion	Effect
		Water quality degradation	Effect
		Urbanization	Cause
		Increase in industrial and mining activities	Cause
		Changes in water quantity and seasonal flows	Effect
		Coastal erosion downstream of the Volta Basin	Effect
		Invasive aquatic species	Effect
		Increased sedimentation of river courses	Effect
		Loss of soil and vegetative cover	Cause
	2013	Agricultural, industrial and domestic pollution of waterbodies	Cause

Table A3. Consolidated causes and effects

Causes Used for the survey	Effects Used for both the survey and the analytical framework	
Deforestation	With respect to water quantity	Permanent or seasonal flooding due to natural causes
Natural hydrology		Permanent or seasonal flooding due to anthropogenic causes
Anthropogenic changes to hydrology		Permanent or seasonal inadequate water due to natural causes
Climate change		Permanent or seasonal inadequate water due to anthropogenic causes
Land use change	With respect to water quality	Permanent pollution due to anthropogenic reasons
Poor land use		Unnatural turbidity due to anthropogenic reasons
Infrastructure design	With respect to the environment	Biodiversity loss or compromise
Infrastructure operation		Habitat loss or compromise
Poor WRM		Morphological change
Regulatory inadequacies		Compromised human health
Inadequate data and information		
Poor disaster planning		
Unregulated effluent		

ANNEX 3. DEVELOPMENT OF THE SOLUTION AXIS

The elements of the solution axis of the analytical framework were developed using the following methodology.

First, the five categories of nexus solutions proposed by UNECE[187] were reorganized into four mezzanine factors (Table A4). Next, the mezzanine factors were unpacked into subsidiary factors (see Table A5) using the "package of solutions" proposed in the NWSAS Nexus Assessment[188,189] (see section 6.2, NWSAS case study). The subsidiary factors were then translated into component elements of the solutions axis (see Table A6).

Table A4. Derivation of mezzanine factors

Clusters of solutions		Mezzanine factors	
Institutions	• Inter-sectoral • Multi-level governance • Resource users	• Sharing	International cooperation
Information	• Multi-sector policy supporting • Trans-sector assessments • Guidelines	• Inter-sectoral • Multiple level governance • Resource users • Multi-sector policy supporting • Trans sector assessments	Governance
Instruments	• Economic • Regulatory	• Economic • Regulatory • Plans • Guidelines • Best practice	Economic and policy instruments
Infrastructure	• Built • Natural	• Built • Natural	Infrastructure and innovation
International cooperation and governance	• Sharing • Plans • Best practice		

[187] UNECE, Methodology for Assessing the Water-Food-Energy-Ecosystems Nexus in Transboundary Basins and Experiences from its Application: Synthesis (United Nations, New York and Geneva, 2018).

[188] The choice of the NWSAS package of solutions as a reference is based on the fact that the package is the result of an extensive study and consultation on sectoral and cross-sectoral solutions to basin issues. The NWSAS is the last of a series of basin assessments under the Water Convention and, as such, is the most advanced in terms of coverage of nexus solutions.

[189] UNECE, GWP-Med, OSS, Reconciling Resource Uses: Assessment of the Water-Food-Energy-Ecosystems Nexus in the North Western Sahara Aquifer System Part A – "Nexus Challenges and Solutions" (UNECE, Geneva, 2020). Available at: https://unece.org/environment-policy/publications/reconciling-resource-uses-assessment-water-food-energy-ecosystems.

Table A5. Derivation of subsidiary factors

Senior cluster	Sector	Original action	Discussion	Subsidiary factors carried forward for framework design
International cooperation	Water	Enhance local water management, including by revitalizing participatory models at oases and enhancing the enforcement of existing laws on water	Not relevant as local water management is by definition not transboundary, with the possible exception of the aquifer (which would be captured in A1).	Not applicable
		Reinforce transboundary cooperation for sustainable groundwater resource management	Highly relevant	A1 Sustainable and productive natural resource management as a result of stronger transboundary cooperation
	Energy	Enhance mechanisms for the coordination of energy development with other sectoral plans to anticipate trade-offs and build on intersectoral synergies	Highly relevant	A2 Increased awareness concerning the benefits of and options for cross-sectoral, transboundary trade-offs, compromise and synergies
	All water-using sectors			A3 New multi-purpose basin-level infrastructure and multi-purpose use of existing basin-level infrastructure optimized as a result of trans-sector governance and international cooperation
	Ecosystem	Upgrade inter-sectoral cooperation based on a detailed "water balance" of the aquifer that includes sectoral demands as well as environmental needs	If articulated in terms of information exchange and management, this would be highly relevant, but in actuality it concerns cooperation.	Adequately captured by B1

Senior cluster	Sector	Original action	Discussion	Subsidiary factors carried forward for framework design
Governance	Water	Upgrade inter-sectoral cooperation based on a detailed "water balance" of the aquifer that includes sectoral demands as well as environmental needs	Included in the "Economic Policy and Instruments" cluster. If articulated in terms of information exchange and management, then this is highly relevant and is captured in B1.	B1 Sustainable and productive management and exploitation of natural resources as a result of shared planning and monitoring information and common metrics, not least with respect to mandatory environmental and social impact assessment
	Food	Valorize local products and strengthen programmes for a more balanced diet, while involving young people and women in economic and social development of the oases	Nil relevance because these are socio-economic actions at a local, not transboundary level	Not applicable
	Energy	Develop a sustainable programme for diversified, multi-purpose renewable energy and the sustainable upscaling of small-scale solar irrigation	Included in the "Economic Policy and Instruments" cluster in Annex 3. However, this raises the question of what is multi-purpose energy. Regardless, this should concern multi-purpose infrastructure, and as such, already has an appropriate objective in this cluster as well as the governance cluster.	B2 New multi-purpose basin-level infrastructure and multi-purpose use of existing basin-level infrastructure optimized as a result of appropriate incentive structures and well-enforced regulations (note that this is not the same as A3).
	Ecosystem	Systematize environmental and social impact assessment for all new infrastructure (regardless of scale)	Included in the "Infrastructure and Innovation" cluster in Annex 3. However, this is really a governance issue, which in transboundary terms also involves the need for common metrics.	Adequately captured by B1

Senior cluster	Sector	Original action	Discussion	Subsidiary factors carried forward for framework design
Economic policy and instruments	Water	Set up dedicated policies and related incentives for wastewater reuse in agriculture and urban areas	It remains unclear exactly how this is a nexus action, with a "dedicated" policy likely to become a siloed policy. Not needed for the analytical framework.	Not applicable
	Water	Strengthen water demand management including through water saving programmes	The term "saving" is considered troublesome by some experts. If a farmer "saves" water, it is unclear whether the water belongs to the farmer, society, the state or the environment. It is more advisable to think in terms of reallocation of water that is no longer needed at a given location rather than savings – hence C1	C1 Water demand management improved by a combination of smart economic policies along with institutional and legal arrangements that increase the economic mobility of water
	Food	Set up agricultural policies oriented towards reasonable, sustainable and productive agriculture	This is a policy issue, so the relevance to governance and international cooperation may not be evident, unless it concerns transboundary trade within a river basin. If this is the case, it is of profound relevance because responsible trade is needed to extract value from natural resources in a sustainable fashion.	C2 Transparent and equitable terms of transboundary trade within a river basin
		Promote the circular economy including agroecological practices by means of ad-hoc economic measures and social instruments	Not relevant, as agroecological practices are not transboundary investments, especially as in this case they result from ad-hoc measures and instruments.	Not applicable

Senior cluster	Sector	Original action	Discussion	Subsidiary factors carried forward for framework design	
Infrastructure and innovation	Energy	Develop a sustainable programme for diversified, multi-purpose renewable energy and the sustainable upscaling of small scale solar irrigation	Included in the "Economic Policy and Instruments" cluster. But for analytical purposes this has infrastructural implications – hence D1, and decentralized service concepts (i.e. along mixed energy pathways) – hence D4 (below)	D1	New multi-purpose basin-level infrastructure and multi-purpose use of existing basin-level infrastructure
	Water	Upscale the use of non-conventional water resources through desalination and wastewater treatment	This is too specific, and needs to be captured in a more generalized fashion	D2	Water, energy, agriculture and environmental security enhanced, basin-wide as a result of innovations in infrastructure financing and operating rules, especially when due to multi-purpose paradigms
	Food	Enhance innovative practices and techniques for sustainable soil and crop management and invest in their upscaling and dissemination	This can and is interpreted to mean the holistic role that appropriate agribusiness concepts could reflect in their plans.	D3	Water, energy, agriculture and environmental security enhanced, basin-wide as a result of landscapes restored or transformed by investments in natural infrastructure or appropriate agribusiness operations
	Energy	Improve the reliability of electrical grids in the rural areas, thereby enhancing the integration of renewables for remote and multiple uses	The issue here concerns the relationship between scale and decentralization	D4	Water, energy, agriculture and environmental security enhanced, basin-wide as a result of increased use of decentralized service concepts and infrastructure
	Ecosystem	Increase awareness of the trade-offs and synergies between different sectors in public institutions	Highly relevant	Adequately captured by A2	

Table A 6. Derivation of component elements

Mezzanine factor	Subsidiary factor	Component elements
International cooperation	Sustainable and productive natural resource management as a result of stronger transboundary cooperation	Stronger transboundary cooperation
	Increased awareness concerning the benefits of and options for cross-sectoral, transboundary trade-offs, compromise and synergies	Increased awareness of the benefits accruable to cross sector transboundary trade-offs, compromise and synergies
		Increased awareness of options for cross-sector, transboundary trade-offs, compromise and synergies
	New multi-purpose basin-level infrastructure and multi-purpose use of existing basin-level infrastructure optimized as a result of trans-sector governance and international cooperation	New, multi-purpose basin-level infrastructure
		Multi-purpose use of existing infrastructure
Governance	Sustainable and productive management and exploitation of natural resources as a result of shared planning and monitoring information and common metrics, not least with respect to mandatory environmental and social impact assessment	Shared data and information
		Common metrics
		Standardized social and environmental impact assessments
	New multi-purpose basin-level infrastructure and multi-purpose use of existing basin-level infrastructure optimized as a result of appropriate incentive structures and well-enforced regulations	Functional, transparent incentive structure
		Appropriate, well enforced regulations

Mezzanine factor	Subsidiary factor	Component elements
Economic and policy instruments	Water demand management improved by a combination of smart economic policies along with institutional and legal arrangements that increase the economic mobility of water	Demand management policies
		Legal arrangements for demand management
		Institutional arrangements for demand management
		Economically mobile water
	Transparent and equitable terms of transboundary trade within a river basin	Transparent and equitable terms of transboundary trade between the riparian states
Infrastructure and innovation	New multi-purpose basin-level infrastructure and multi-purpose use of existing basin-level infrastructure	Multi-purpose infrastructure
		Innovative infrastructure
	Water, energy, agriculture and environmental security enhanced, basin-wide as a result of innovations in infrastructure financing and operating rules, especially due to multi-purpose paradigms	Innovative financing
		Innovative infrastructure operating rules
	Water, energy, agriculture and environmental security enhanced, basin-wide as a result of landscapes restored or transformed by investments in natural infrastructure or appropriate agribusiness operations	Natural infrastructure
		Appropriate agribusiness
	Water, energy, agriculture and environmental security enhanced, basin-wide as a result of increased use of decentralized service concepts and infrastructure	Decentralized service delivery concepts
		Decentralized service infrastructure

Solutions and investments in the water-food-energy-ecosystems nexus

A synthesis of experiences in transboundary basins

Water resources and ecosystems underpin socio-economic developments in energy and agriculture as well as in industry, tourism, navigation and other sectors. However, these developments also exert significant pressure on the environment, with impacts on the availability and quality of water. Tackling water and environment-related issues through nexus solutions means understanding inter-sectoral linkages and addressing them through coordinated action. In transboundary basins, the design and implementation of nexus solutions is a complex process that must reconcile diverse interests and sectoral needs. However, the process is a necessary one as transboundary basins account for around 60 percent of global freshwater flows.

The purpose of this publication is to support governments and other public and private actors in designing and implementing nexus solutions and investments that create synergies and provide transboundary benefits. Building on a wealth of accumulated experience, it offers policymakers and practitioners an overview of the problems that nexus solutions have helped tackle, crucial factors in their success and the main challenges encountered during implementation. It also presents lessons learned from regional dialogues that provide important insights into upscaling nexus solutions in transboundary contexts, with a focus on financing and enabling environments.

This publication draws extensively on several Water-Food-Energy-Ecosystem Nexus Assessments carried out under the Convention on the Protection and Use of Transboundary Watercourses and International Lakes as well as the experience of key partners (e.g. the International Union for the Conservation of Nature, the Global Environment Facility, and the German Agency for International Development (GIZ)) all of whom are working to promote transboundary and regional cooperation across sectors. The lessons learned from these dialogues are particularly relevant for the successful implementation of the Agenda 2030 for Sustainable Development, which requires strong cross-sectoral cooperation.

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