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Working Group on Integrated Water Resources Management

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Item 8 of the provisional agenda
Thematic assessment of the water-food-energy-ecosystems nexus

Methodology for assessing the water-food-energy-ecosystems-nexus in transboundary basins

Prepared by the secretariat in cooperation with the Royal Institute of Technology in Stockholm

Summary

At its sixth session (Rome, 28–30 November 2012), the Meeting of the Parties to the Convention on the Protection and Use of Transboundary Watercourses and International Lakes requested the Task Force on the Water-Food-Energy-Ecosystems Nexus, in cooperation with the Working Group on Integrated Water Resources Management, to prepare a thematic assessment focusing on the water-food-energy-ecosystems nexus with a view to its publication prior to the seventh session of the Meeting of the Parties (see ECE/MP.WAT/37, para. 38 (i)).

The present document describes the methodology developed for and used in the assessment of the water-food-energy-ecosystems nexus under the Convention. It has been discussed by the Task Force on the Water-Food-Energy-Ecosystems Nexus at its second and third meetings (Geneva, 8–9 September 2014 and 28–29 April 2015), and developed with the oversight of the Task Force. The methodology takes into consideration the experiences from the three basins that have been assessed using this approach.

The document, revised in accordance with any comments from the Working Group, will become one of the chapters of the final publication on the nexus assessment to be submitted to the Meeting of the Parties at its seventh session (Budapest, 17–19 November 2015) for endorsement.

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Contents

Glossary of key terms used in the nexus assessment

Term	*Definition*
Components of the nexus	Water, energy, land use and ecosystems are often referred to as "sectors" and sometimes as "resources". This ambiguity is justified by the fact that they could be considered either way depending on the context of discussion. In a general way, they can be referred to as "components of the nexus".
Ecosystem services	The direct and indirect contributions of ecosystems to human well-being.[a] They are normally divided into "provision", "support", "regulation" and "cultural services".
Ecosystems (component of the nexus)	A dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit.
Energy (component of the nexus)	Energy resources, energy production (including electricity), transportation/transmission of energy and energy access (clean, constant and safe).
Energy productivity	The ratio between the wealth produced by a certain activity and the energy used to produce it. It can refer to the overall economy of a country or to a single sector/activity.
Food (component of the nexus)	Land resources and types of land use, with a strong focus on agriculture (crop production, fishing and livestock), but considering also urban areas, forestry, etc. Due to the scope of the assessment, the food component of the nexus is commonly referred to as agriculture or land.
Governance	The rules and mechanisms that characterize how a society functions. Specifically, the governance analysis of a nexus assessment looks at the legislative, institutional and policy framework of the basin, the countries and the region.
Integration	The act of considering different sectors (or institutions) together. In general terms, better integration means improved cooperation, communication and collaboration. Integrated modelling refers to the merging of different models (e.g., the energy model and the water model) to obtain combined results.
Interdependency	A relation of mutual dependency or influence, here referring to sectors or actors involved in the assessment.
Interlinkage (between sectors)	Relations existing between two sectors. They may be unidirectional (impact from one sector on another) or bidirectional (trade-offs, affecting each other).
Modelling	The conceptualization of a system using quantitative and spatial information to allow for the representation of resource flows and evolutions. This is usually done using appropriate tools.
Nexus	The nexus term in the context of water, food (agriculture) and energy refers to these sectors being inextricably linked so that actions in one area commonly have impacts on the others, as well as on ecosystems that provide vital services to these sectors.
Nexus issue	A problematic situation that affects more than one sector.

Term	*Definition*
Nexus solution	An intervention that would benefit more than one sector, in this context including also interventions that reduce the pressure on ecosystems (or the environment at large).
Policy coherence	Policy coherence implies that the incentives and signals of different policies to target groups are non-conflicting. Policy coordination and policy integration help to increase coherence, introducing processes and means that reduce coherence problems between sectors.[b]
Reconciling (different uses)	Finding solutions to tensions or conflicts related to the multiple needs/uses of a common resource.
Resource scarcity	A resource can be scarce in absolute or relative terms. In the first case, scarcity refers to a physical lack of availability (e.g., water scarcity means aridity). In the second case, scarcity is related to the uses of such resource. A large demand of one resource simply reduces its availability for other uses.
Scenario	An expected or possible situation characterized by certain conditions. Usually, factors such as climate change or important policy actions serve to characterize such scenarios.
Sector	In general terms sectors are resource users. They can be both productive (e.g., industry) and consumptive (e.g., households).
Synergy	A synergy is an action that two or more actors take together. By coordinating, the parties normally need to invest less effort than by acting separately.
Trade-off	A balance achieved between two desirable but incompatible features; a sacrifice made in one area to obtain benefits in another.[c]
Water (component of the nexus)	Water resources and their management, water services (utilities, infrastructure including irrigation schemes) and water access (safe drinking water, sanitation)
Water productivity	The ratio between the wealth produced by a certain activity and the water used (withdrawn) to produce it. It can refer to the overall economy of a country or to a single sector or activity.
Water-food-energy-ecosystems nexus	An extension of the traditional water-food-energy nexus, the water-food-energy-ecosystems nexus gives a more prominent role to ecosystems and the services they provide. It should be noted that the present assessment's food component focuses on agriculture (sector) and land (resource) management- related aspects.

[a] Definition from The Economics of Ecosystems and Biodiversity (TEEB) website www.teebweb.org/resources/glossary-of-terms/.

[b] For a review of the terms and some relevant literature, see, e.g., Per Mickwitz and others, *Climate Policy Integration, Coherence and Governance* (Helsinki, Partnership for European Environmental Research, 2009).

[c] Definition from the Oxford English Dictionary.

I. Background and proposed action by the Working Group on Integrated Water Resources Management

1. An assessment of the water-food-energy-ecosystems nexus in a selected number of transboundary river basins is being carried out as part of the programme of work for 2013–2015 of the United Nations Economic Commission for Europe (ECE) Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) (ECE/MP.WAT/37/Add.1, programme area 5). The objectives of the nexus assessment are:

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

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

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

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

3. To develop the methodology, the ECE secretariat, guided by the Task Force, adopted an evolutionary "learning-by-doing" process: a draft methodology was developed, circulated for review, tested in practice and further reviewed.

4. The methodology presented in this document is the result of reviews at the second and third meetings of the Task Force (Geneva, 8–9 September 2014 and 28–29 April 2015, respectively). It takes into consideration the experiences from the three basins already assessed using the nexus approach: the Alazani/Ganykh, shared by Azerbaijan and Georgia; the Sava, shared by Bosnia and Herzegovina, Croatia, Montenegro, Serbia and Slovenia; and the Syr Darya, shared by Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan. It is expected that the methodology will be applied in additional basins.

5. This version of the methodology document includes all the improvements made and provides a better, tested format and organization for future application of the nexus assessment methodology. The main change from the previous version is the merging of the governance aspects — initially described in a separate methodology document[1] — with the rest of the methodology, as their treatment has evolved since then. In the light of the experience from the consultation meetings held in Azerbaijan and Georgia in February 2015, a follow-up meeting with national authorities has been added as a further step in the nexus assessment process.

6. In addition to the improvements that were tested and used in the assessment of the basins, some further suggestions for developing the methodology that have emerged from the work are illustrated in this document.

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

7. The need for an intersectoral approach to policymaking, as well as the value added of a nexus approach to integrated water resource management, are described in the chapter on the application of a nexus approach in transboundary basins (see "Chapters on selected aspects of the water-food-energy-ecosystems nexus" (ECE/MP.WAT/WG.1/2015/6)).

8. The Working Group on Integrated Water Resources Management may wish:

(a) To review and endorse the methodology for assessing the water-food-energy-ecosystems nexus in transboundary basins as described in the present document;

(b) To express its appreciation to the experts from the Royal Institute of Technology (KTH, Stockholm), the University of Geneva, the Central European University, the Food and Agriculture Organization of the United Nations and the Water Convention secretariat for the substantive work done;

(c) To review the assessments for the Alazani/Ganykh, Sava and Syr Darya Basins, in which the methodology has been applied (see informal documents WG.1/2015/INF.4, WG.1/2015/INF.5 and WG.1/2015/INF.6), and to endorse them in terms of general content, while inviting the concerned riparian countries and stakeholders to provide any necessary corrections to these basin assessments by 13 July 2015;

(d) To entrust the secretariat, in cooperation with the Bureau and the Chair of the Task Force, to address the comments received, if any, integrate the different chapters and finalize the thematic assessment for publication, including by performing the needed editing and shortening to meet editorial requirements, and subsequently to design, publish and print the assessment for submission to the Meeting of the Parties at its seventh session (Budapest, 17–19 November 2015). The thematic assessment will be presented as an official printed publication and not an official document to the Meeting of the Parties in order to facilitate and accelerate improvement of intersectoral coordination and related transboundary cooperation in basins around the world. The English original will be presented to the Meeting of the Parties, with French and Russian translations to follow.

II. Nexus assessment methodology[2]

9. The methodology developed for assessing the water-food-energy-ecosystems nexus in transboundary basins provides for the identification of positive and negative linkages, benefits and trade-offs among sectors at the national and transboundary levels, assessing their relative importance and exploring their development in the future, taking into account climatic and socioeconomic changes. The methodology also sets a basis for the quantification a number of these features. Depending on the setting, the nexus issue and data availability, appropriate quantification tools for specific analyses can be identified.[3] The information generated by the nexus assessment of a basin can help in the coordination of policies and actions across sectors, institutions and countries. But, even more importantly, the process involves an intersectoral dialogue in a transboundary context that is informed by a joint assessment. In the end, the nexus methodology leads to the identification of concrete actions to reduce tensions between sectors and countries.

[2] The methodology development team: KTH — Lucia de Strasser, Mark Howells, Tom Alfstad, Holger Rogner and Manuel Welsch; the University of Geneva — Christian Bréthaut; the Central European University — Stephen Stec; ECE — Annukka Lipponen; and FAO — Lucie Pluschke.

[3] Some possible tools for intersectoral analysis are described in a devoted chapter. At the scoping level, for assessments carried out in the framework of the Convention's programme of work for 2013–2015 the quantifications have been relatively limited.

A. Principles

10. In connection with the aims of the transboundary nexus assessment, and in order to ensure achievement of the objectives (see para. 1 above), a core set of features should characterize the approach adopted:

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

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

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

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

(e) *Collective effort* — The outcome of the nexus assessment will reflect the broad range of views and expertise involved throughout the process, including those of Parties to the Water Convention and other States;

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

11. As such, the countries participating in a nexus assessment will benefit from:

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

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

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

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

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

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

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

B. Emphasis on participation in this collaborative assessment

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

13. In particular, according to a recent study[4] consulting various stakeholders and incorporating their views in a nexus assessment from the very beginning is instrumental for its success and ensuring its responsiveness to specific needs and circumstances. Effective stakeholder engagement in a nexus approach should include consultations with:

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

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

(c) Practitioners[5] who can quantify and prioritize various nexus issues;

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

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

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

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

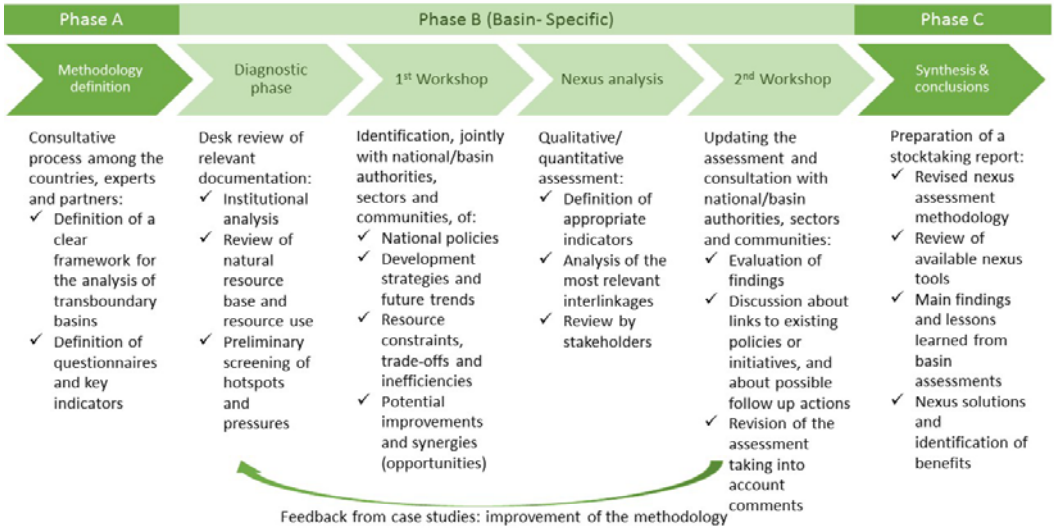
[5] The term refers to individuals who work in the relevant sectors, in this context in resource management or in environmental protection.

C. Phases of work 2013–2015

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

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

Figure 1
Phases of work



Phase A

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

19. Since the beginning of the assessment process under the Water Convention, it was planned that the application of this methodology to the basins (Phase B) would serve as a test of the appropriateness of the methodology and that the respective lessons learned would be used to improve it. This helps to increase the value and usefulness for future basin assessments. The basins that this methodology can be used to analyse may be very different. Hence, the objective is to come up with a simple structure that can be replicated in each basin, allowing at the same time a high degree of flexibility, responding to different circumstances and sets of intersectoral issues.

Phase B

20. Phase B, which consists of six steps (see table 1), has several objectives, including:

(a) To identify nexus issues.[6] Selected examples that illustrate the need for cooperation may be quantified;

(b) To identify potential nexus solutions.[7] Selected examples of benefits may also be quantified;

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

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

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

21. The assessment of the basin evolves on two main tracks: the analysis of natural resources and the analysis of governance.[8] These are parallel and complementary efforts that inform each other. The first track of analysis looks at the geography, climate, resource uses and flows, as well as the physical linkages between sectors. The second track aims at capturing the relevant features of the legal basis, institutional framework and the main policies, with a focus on policy coherence, as well as gaps, overlaps and complementarities of responsibilities.

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

Phase C

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

III. Nexus assessment of a transboundary basin

A. Assessment process

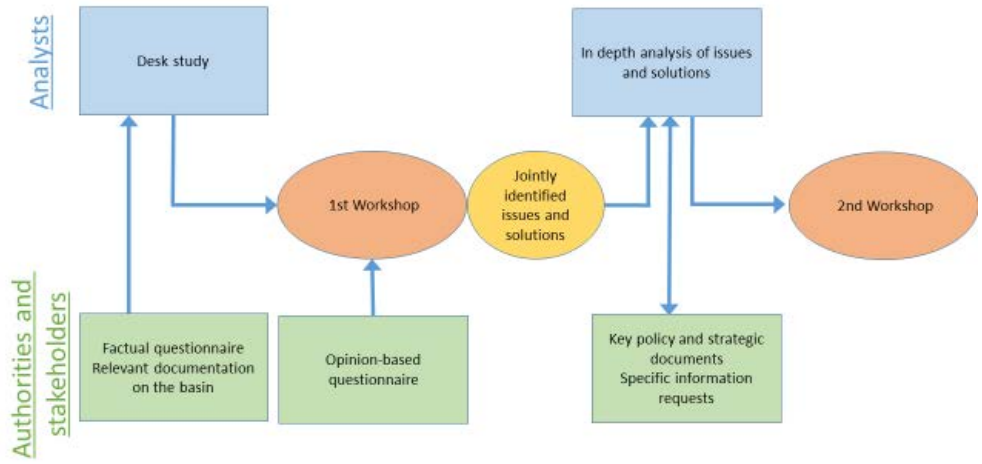
24. The nexus assessment of a basin involves analysts, authorities and various stakeholders. Their role in the assessment process is illustrated in figure 2.

[6] A problematic situation that affects more than one sector

[7] An intervention that would benefit more than one sector

[8] The governance analysis covers the institutional framework, legal basis and the main policies (see Glossary of terms)

Figure 2
Information exchange in the nexus assessment of a basin



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

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

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

Table 1
Steps of the nexus assessment of a basin

Step	*Actors*	*Location*	*Sectors*
1 Identification of basin conditions and the socioeconomic context	Analysts	Desk study	General. Information normally used to underpin sectoral planning. Key elements include general socioeconomic goals and targets.
2 Identification of key sectors and stakeholders to be included in the assessment	Analysts and authorities	Desk study	General. Requires expert judgment and understanding of local context and governance.
3 Analysis of the key sectors	Analysts and authorities	Desk study/ first workshop	Individual sector experts and plans. Key elements include identification of the resource base and uses, as well as institutional mapping.
4 Identification of intersectoral	Stakeholders	First workshop	Sectoral group discussion on

Step	*Actors*	*Location*	*Sectors*
issues			interlinkages (input needs, impacts and trade-offs), and discussion on sectoral plans.
5 Nexus dialogue and future developments	Stakeholders	First workshop	Agree on a prioritization of main interlinkages, including how they are expected to change, according to jointly identified development trends, noting key uncertainties and most important drivers.
6 Identification of opportunities for improvement (across the sectors and countries)	Stakeholders and analysts	Desk study, first and second workshops	Identification of solutions with multiple impacts between sectors, scales and boundaries. Such solutions could eventually be integrated into policies and programmes in the countries/basins.

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

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

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

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

Step 1
Identification of basin conditions and the socioeconomic context

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

(a) **The needs of the population living in the basin area**, among others, meeting basic human needs (such as water, food, energy and environmental security), poverty reduction or the improvement of socioeconomic conditions, economic development

and a healthy environment, or to address factors that compromise human well-being in these terms. These needs may or may not be satisfied, which means people and local activities may or may not have access to the resources they need to develop;

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

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

34. In order to pursue the double aim of this step (identifying the needs of the population and the relations between the region, the basin and the riparian countries) efficiently, it is advisable to proceed along two parallel, complementary paths involving the necessary expertise. An analyst (or a team of analysts) should look at the basin and its population from the perspective of the availability of and access to resources. Another analyst (or a team of analysts) should look at it from a governance perspective, starting to define the institutional framework of the water, energy, agriculture/land use and ecosystems components of the nexus.[9] This involves a mapping of actors (ministries, State agencies, basin organization, regional and local authorities, and the private sector, including utilities and civil society) that influence the management of resources in the different areas of the nexus at the local, basin, national and regional levels, together with their interrelations, which could be organizational structures as well as agreements and important joint efforts. The governance analysis seeks to uncover potentially conflicting objectives of sectoral policies as well as shortcomings in administrative practice and philosophy that interfere with the resolution of such conflicts. At this stage, the mapping exercise is aimed at understanding the dynamics across scales (region, basin, countries). A more detailed mapping of actors will be further developed for each key sector in step 3.

35. In order to describe the natural resource base that allows a response (or not) to the needs, readily available and tested indicator sets are used. For an accurate assessment, basin or local level information would be ideal, but, in the case of many basins, national level information will need to be used as a proxy in the absence of more detailed data. A typical example is the lack of access to water and sanitation, which is normally only available at country or province level. These indicators can be complemented with quantitative and qualitative information at basin level or at a local administrative level.[10] The existence of a well-established basin organization that can compile and coordinate consistent statistics at the basin level will be very valuable — not only to obtain basin level indicators, but also to

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

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

estimate the accuracy of the proxies used from national statistics. The degree of harmonization of data by national authorities varies greatly depending, for example, on the region and on the level of cooperation on information sharing.

36. The governance analysis, in parallel, needs to start with a mapping of actors, mandates and important regional dynamics, such as the relations of riparian countries with external economic and political players. In this first stage of the governance analysis, it is possible to capture the main strategic goals that characterize the economies of the riparian countries. Because of the broad spectrum of analysis — spanning from water governance to energy markets, to environmental management and agricultural development — the analysts would greatly benefit from existing sources of knowledge[11] about the basin and the region.

37. Helpful inputs for this step include the outcomes of a factual questionnaire screening the water, agriculture/land, energy and ecosystem resources. This first screening of the basin and information, gathered directly from focal points[12] in the countries through a questionnaire, inform the desk study, compiling relevant existing information and earlier studies. Particular attention is paid to documentation referred to by the participating authorities.

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

Outputs of step 1

39. The key outputs of step 1 were:

(a) Factual questionnaires targeting each riparian country;

(b) Responses to the questions:

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

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

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

Improvements to step 1

40. At the beginning of the nexus project (the assessment of the Alazani/Ganykh Basin), the governance analysis and the analysis of resources and needs were not sufficiently synchronized. The analysis of the basin was set up with a team of experts looking at the

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

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

resources and needs, to be complemented by a separate institutional analysis. This scheme was improved in the course of the project (in the assessments for the Sava and the Syr Darya Basins) and the institutional analysis evolved into a proper governance analysis, which covered not only institutional aspects, but also the legal basis and the policy framework, and which made it possible for the other team to focus more on the physical aspects of the nexus. The dialogue was also improved between the two teams. A further improvement would be strengthening the dialogue between experts even more, ideally working in the same place with a common schedule. Assigning different teams of analysts to the development of a resource assessment and a governance analysis is not necessary as long as the team in charge of the nexus assessment possesses all the necessary expertise. In addition, the economic aspects of the nexus — currently part of the governance analysis (see annex IV) — would similarly benefit from the inputs of qualified experts.

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

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

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

43. In view of the upcoming first workshop and its follow-up activities, which depend on stakeholders' active participation (steps 4–6), step 2 also helps in identifying who these stakeholders should be. It is important to involve a diverse group representing key actors and other stakeholders, including policymakers, experts and civil society, that can contribute to the assessment both with their knowledge and their power to take action. The key actors and other stakeholders to be involved include national and local government institutions of the main relevant sectors (most commonly water, energy and agriculture sectors), environmental protection authorities and, where feasible, local communities.[13] As appropriate, involvement of the private sector and civil society is also sought. In addition, involving experts who are involved in relevant work in the basin is also highly beneficial. Relevant work includes work in the area of climate change adaptation, environment and governance, as well as current and past efforts to improve intersectoral cooperation between the water, energy and agricultural sectors in the region.

Outputs of step 2

44. The key outputs of step 2 were answers to the questions:

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

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

(b) Who are the key stakeholders to involve in the assessment?

Improvements to step 2

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

Step 3
Analysis of the key sectors

46. In step 3, each of the key sectors identified in step 2 is analysed, following roughly the logic of the Driving forces-Pressures-State-Impacts-Responses (DPSIR) framework.[14] As mentioned earlier, the water, energy[15] and agricultural sectors form the core group of key sectors. Others may include a particular industry, tourism, navigation and sub-sectors of agriculture (e.g., fishing or forestry). It is important to ensure representation of environmental protection interests — both environmental authorities and civil society groups working on the environment — in addition to economic interests.

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

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

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

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

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

(b) **Pressures and impacts**: effects on the environment and the impact on humans and ecosystems. The sectors contribute to the economy by meeting local needs and achieving national objectives. Here, it should be considered which services each sector provides and what impacts they have. For example, safe drinking water is a "service"

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

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

supplied by the water sector. An impact of the sector might include depletion of water resources owing to heavy abstraction. Poor health of the population may be a resulting impact of inadequate water sector management;

(c) **Setting (state)**:

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

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

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

c. The definition of a hydrological model[16] of the basin;

d. An understanding on the main ecosystems (e.g., glaciers, wetlands, forests, etc.) and the services they provide;[17]

(ii) *Institutions and governance* . Looking at each sector, the institutional and legal framework is reviewed and presented in the form of a graphical scheme. Drawing from the previous efforts (step 1), intersectoral, local-national as well as transnational agreements and mechanisms are now presented in terms of sectoral institutional settings and activities. This will allow the analyst to study and compare mandates and responsibilities as well as identify institutional gaps or dysfunctional mechanisms that need better coordination;

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

Outputs of step 3

48. The key outputs of step 3 were:

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

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

[17] According to the many classifications, ecosystems services are divided into four groups: provisioning; supporting; regulating; and cultural. For definitions and examples please see “Ecosystems Services” on the TEEB website (http://www.teebweb.org/resources/ecosystem-services/).

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

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

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

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

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

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

Improvements to step 3

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

50. The extent to which the analysis of natural resources varied in the three basins already assessed was influenced by the availability of data and access to tools and resources. Even though it was not strictly part of the envisaged process, it became clear that limited modelling was needed to be able to provide illustrative quantification of interlinkages across sectors. In future assessments, the need for such modelling should be foreseen. If there are specific issues that the countries want to look at, quantification can be focused on the issue at stake, ideally using already available models and liaising with local research institutes. A modelling exercise can be also valuable to advance capacity-building.[18]

Step 4
Identification of intersectoral issues

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

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

53. The opinions of the participants are collected to appreciate the differences in perspective by country and sectoral affiliation. These can be presented in the course of the workshop to show what everyone agrees on and what is viewed differently from different sectors or countries.[19]

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

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

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

55. Participants at the workshop are then divided into sectoral groups[20] to focus on and analyse each component of the nexus. They are asked to consider the component's sectoral plans (including the time frame) and their links to other components as resource input requirements (for example, the energy sector's water needs for hydropower generation or cooling).

56. The key activity in this step is for participants to consider linkages of their sector with other sectors and the implications thereof. Relevant intersectoral relations and impacts from each sector's point of view are captured. The discussion can be extended to where in the basin the interlinkages are most prominent by looking a thematic GIS map of the basin. Thematic presentations for each sectoral group can be prepared on the basis of the desk study to start the discussion.[21]

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

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

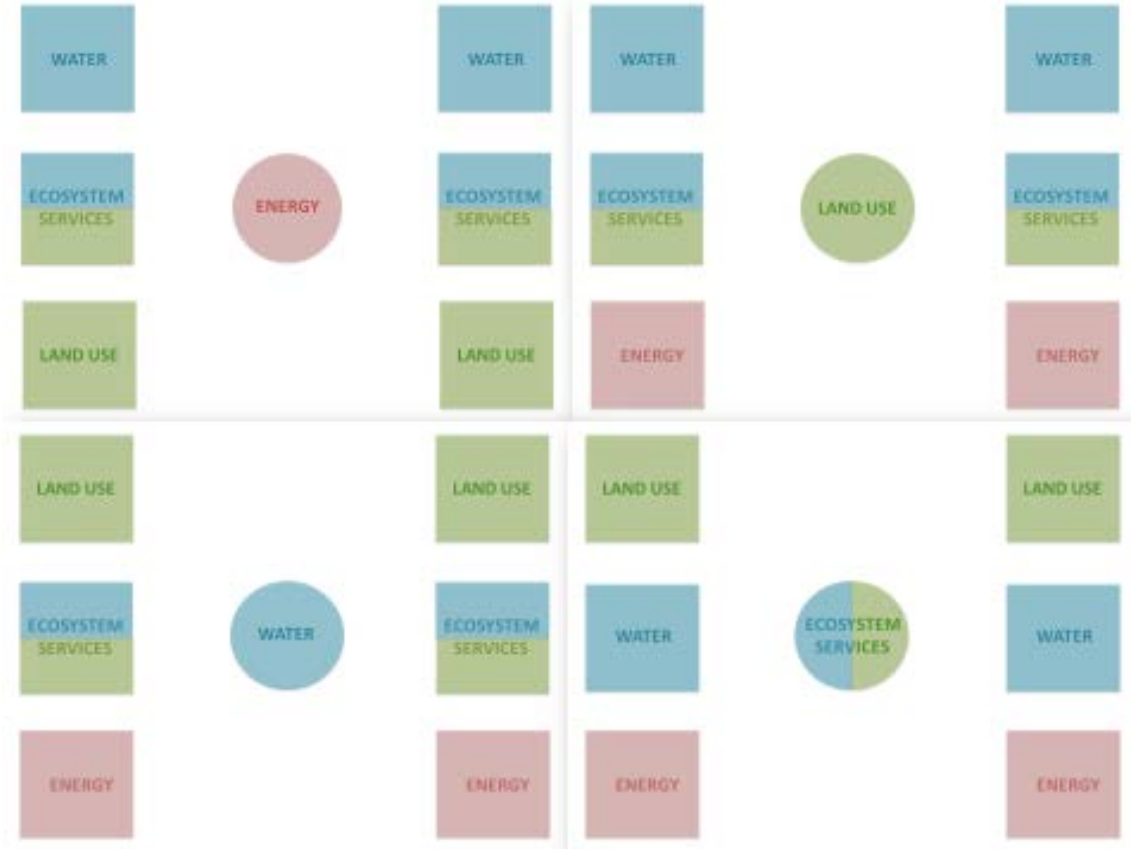
Outputs of step 4

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

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

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

Figure 3
Diagrams of each sectoral group for the purpose of identifying intersectoral issues



Improvements to step 4

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

Step 5
Nexus dialogue

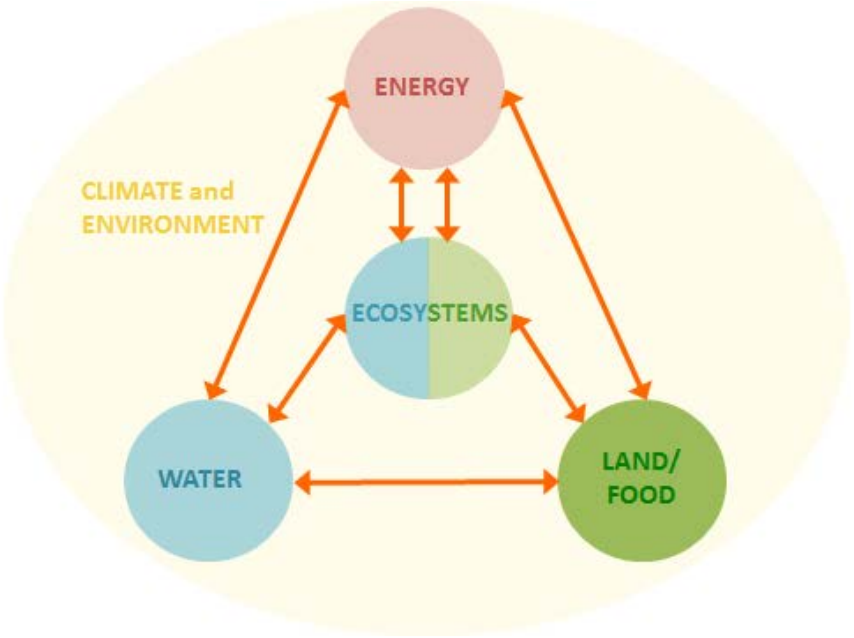
61. A nexus diagram, including links between sectors, is drawn collectively in the first workshop. This pictures all sectors as equally important. Links identified in step 4 from a sector perspective are considered in step 5 and jointly prioritized. The links might be unidirectional (impact of one sector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

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

63. As the next workshop activity, the relevant future tendencies are identified jointly with the participants: scenarios are developed, and the effects between sectors are qualitatively described. This was initially done in very general terms, discussing in plenary session socioeconomic trends (population growth, economic development, etc.), strategic

directions of the sectors, priorities of the countries and external constraints, such as climate change. In the last workshop, an attempt was made to focus this discussion more on the future dimension and to make it more interactive. It was decided to take one session and use it to build scenarios in working groups, define key uncertainties and discuss the evolution of the identified interlinkages in those scenarios.

Figure 4
Nexus dialogue: agreed key interlinkages



Outputs of step 5

64. The key outputs of step 5 were:

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

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

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

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

Improvements to step 5

65. In the last workshop[22], the working group session to discuss the future dimension was designed on the basis of the "Scenario Thinking" exercise developed by the Food and Agriculture Organization of the United Nations (FAO).[23] According to FAO, in previous applications, this exercise was carried out for the entire duration of a workshop and gave very satisfying outcomes. While the time was reduced to three hours, the procedure was not

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

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

sufficiently modified to fit such a short time slot. In future applications, this session will need to be redesigned and its required outputs better defined.

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

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

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

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

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

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

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

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

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

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

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

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

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

72. Transboundary water cooperation has the potential to generate diverse and significant benefits for cooperating countries. Those benefits can be realized by

accelerating economic growth, increasing human well-being, enhancing environmental sustainability and contributing to political stability. Commonly the understanding of possible benefits is narrowly focused on sharing (volumes of) water. The intersectoral or nexus approach invites consideration of the intersectoral implications of policies and management measures, and the related opportunities for benefits in a broad sense. Assistance in recognizing wide-ranging benefits is available from the policy guidance note on identifying, assessing and communicating the benefits of transboundary water cooperation (see document ECE/MP.WAT/WG.1/2015/4),[24] developed under the Water Convention.

Table 2
Typology of the potential benefits of transboundary water cooperation

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

Source: Draft policy guidance note (ECE/MP.WAT/WG.1/2015/4).

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

[24] Document ECE/MP.WAT/WG.1/2015/4 contains a draft of the policy guidance, which will be reviewed by the Working Group on Integrated Water Resources Management at its tenth meeting. The document is available from http://www.unece.org/env/water/10th_wgiwrm_2015.html#/.

Outputs of step 6

74. The key outputs of step 6 were:

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

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

Improvements to step 6

75. Initially not included among the elements of the methodology, a follow-up meeting with the countries — or second workshop — developed naturally out of the original process, as a forum to discuss findings and the realistic application of nexus solutions. It is now recognized to be one of the key moments of the nexus assessment. Such follow-up workshops have been held as side events of the National Policy Dialogue meetings (co-organized by ECE and the Organization for Economic Cooperation and Development) in the countries of the Caucasus and Central Asia, but these have been national.

76. The assessment seeks to identify a broad range of possible beneficial, synergic actions. A risk and resilience analysis of the identified solutions would seem like a beneficial additional step in the process. However, it should be underscored that with an expert analysis the value of optional solutions can only be taken so far. In the end it is up to the countries to assess what types of actions could be fruitful to pursue and what the political acceptability and technical and economic feasibility of each solution might be. Such a follow-up analysis was beyond the scope of the assessments carried out from 2013 to 2015.

B. Use of indicators

77. The nexus assessment of each basin is data dependent and indicator based. Figure 5 shows how indicators and data relate to the six steps of the basin assessment.

78. The information provided by the national administrations in the riparian countries is the preferred source of data.[25] Where information is already available as reported by national authorities or as country statistics it is gathered directly.

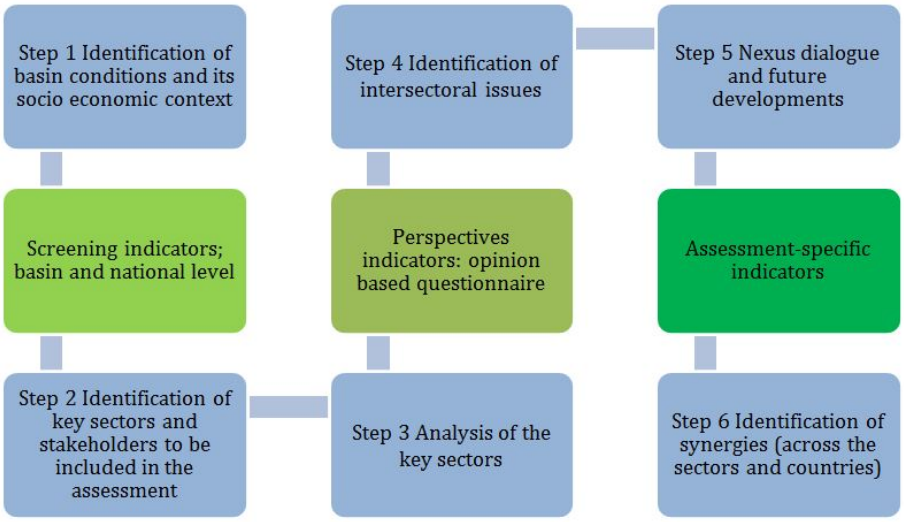
79. The analysis evolves from a diagnostic analysis of the basin and the riparian countries — zooming in on the key sectors — to a participatory phase where intersectoral issues are discussed together, and then proceeds to an in-depth analysis of the main issues identified and potential synergic solutions.

80. Thus, a first set of indicators helps in the diagnosis of the basin. These might be available at national or basin level depending on the topic. The historical or spatial variation of indicators and information is considered whenever relevant (e.g., water quality can be different from point to point; access to safe water can be increasing, decreasing or stable) and whenever available (often, data at basin level are simply not available or they partially overlap with regional or district level data). This group includes also the nexus indicators of FAO that specifically look at the interlinkages across pairs of components (water-energy, food-energy and water-food) and their trends.

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

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

Figure 5
Indicators (in green) and how they are used in the steps (in blue)



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

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

Table 3
Indicators: types and uses

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

Group	*Screening indicators*	*Opinion indicators*	*Assessment-specific indicators*
	information to complement the indicators (for example, types of groundwater use in the basin or water quality).		

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

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

Annex I

Indicators and sources

The table in section A below provides a list of non-spatial indicators, broken down into three groups (screening indicators; perspective indicators; and assessment-specific indicators), along with suggested sources. Section B provides a listing of potential sources for 12 geospatial indicator groups (administrative country data; socioeconomic data; hydrological basins, rivers and irrigation maps; digital elevation; land cover; lakes and wetlands; protected areas; agricultural production area; urban areas; water risks; and forest change), as well as some additional indicator sources.

The list proposed for screening indicators is not comprehensive, but provides a good overview of the basin and its riparian countries.

For all indicators, preference is given to national statistics and indicators received directly from national authorities.

A. Non-spatial indicators

Groups of indicators	*Suggested sources*
I. Screening indicators	
Basin[a]	
Physical characteristics	FAO Aquastat Database[b]
• Length • Basin area • Country's share • Land use by type	ECE Second Assessment of Transboundary Rivers, Lakes and Groundwaters[c]
Withdrawals in the basin: • Total withdrawal • Agricultural share • Domestic share • Industry share • Energy share	FAO Aquastat Database[b]
Transboundary underground aquifers: • Border length, area and thickness, mean and maximum • Main groundwater uses • Groundwater management measures	ECE Second Assessment of Transboundary Rivers, Lakes and Groundwaters[c]

Groups of indicators	*Suggested sources*
Groundwater balance: • Precipitation • Total flow • Inflow • Infiltration river • Infiltration precipitation • Discharge evaporation • Discharge river	ECE Second Assessment of Transboundary Rivers, Lakes and Groundwaters[c]
Renewable water resources in the basin:[d] • Mean annual run-off • Internal renewable surface water resources by country	FAO Aquastat Database[b]
Wastewater information: • Wastewater generated • Wastewater treated (primary, secondary, tertiary treatment)	ECE Second Assessment of Transboundary Rivers, Lakes and Groundwaters[c]
Stress (ranking): • Baseline stress • Inter-annual variability • Seasonal variability • Flood occurrence • Drought severity	World Resource Institute Aqueduct Database[e]
Country	
Gross Domestic Product (GDP): • GDP growth • GDP growth per capita	World Bank World Development Indicators Database[f]
Population: • Population growth • Rural population • Rural population growth • Population density	
Contribution of natural resources to GDP: • Total natural resources rent • Oil rents • Natural gas rents	World Bank World Development Indicators Database[f]

Groups of indicators	*Suggested sources*
• Coal rents • Mineral rents • Forest rents	
Population below national poverty line	
Employment by sector (in agriculture, industry, services)	World Bank World Development Indicators Database[f]
Contribution to total GDP by sector (agriculture, industry, services)	World Bank World Development Indicators Database[f]
Water productivity: • In agriculture • In industry • In services/domestic use	To be calculated on the basis of water withdrawals and GDP (by sector)
Energy productivity: • In agriculture • In industry • In services/domestic use	To be calculated on the basis of energy consumption and GDP (by sector). This information needs to be made available from country statistics (no openly accessible database).
Water resources: • Actual renewable water resources • Internal renewable resources • External renewable resources • Quantity of flow reserved to upstream and downstream countries through formal or informal agreements or treaties • Renewable water resources per capita	FAO Aquastat Database[b]
Water use: • Annual freshwater withdrawal • Withdrawals for agriculture • Withdrawals for industry • Withdrawals for domestic use • Access to improved water source • Access to improved sanitation facilities	World Bank World Development Indicators Database[f] FAO Aquastat Database[b]

Groups of indicators	*Suggested sources*
Land: • Land area • Forest area • Permanent cropland • Arable land • Arable land per person • Total wood resources • Logging harvest (official) • Logging harvest (illegal) • Agricultural irrigated land • Average annual precipitation • Land under cereal production • Fertilizer consumption • Agricultural machinery	World Bank World Development Indicators Database[f]
Energy: • Energy production total • Energy use • Energy use per capita • Use of fossil fuels • Combustible renewable and waste • Alternative and nuclear (including hydropower) • Energy use growth	World Bank World Development Indicators Database[f]
Electricity: • Electricity production: ▪ From coal ▪ From natural gas ▪ From oil ▪ From hydropower ▪ From renewables ▪ From nuclear • Electricity access	World Bank World Development Indicators Database[f]

Groups of indicators	*Suggested sources*
Environment: • Threatened species (mammals) • Threatened species (birds) • Threatened species (fishes) • Threatened species (higher plants) • Terrestrial protected areas • Marine protected areas	World Bank World Development Indicators Database[f]
Emissions: • Carbon dioxide (CO_2) emissions per unit of GDP • CO_2 emission per capita • Total CO_2 emissions	World Bank World Development Indicators Database[f]
II. Perspective indicators	
Difference of opinions by country, by area of expertise (sector): • Overview of the basin • Water quality and quantity • Food and land use • Energy • Environment	Opinion-based questionnaire
III. Assessment-specific indicators	
Interlinkage 1	Previous studies, experts, authorities
Interlinkage 2	
etc.	
Solution 1	
Solution 2	
etc.	

[a] Not all indicators are available for all basins.
[b] Available from http://www.fao.org/nr/water/aquastat/main/index.stm.
[c] United Nations publication, Sales No E. 11.II.E.15. Available from http://www.unece.org/?id=26343.
[d] Information on water mass balance and on the intra-annual distribution of flow would be very useful, the latter also in particular in relation to water uses, which may be highly seasonal.
[e] Available from http://www.wri.org/our-work/project/aqueduct.
[f] Available from http://data.worldbank.org/data-catalog/world-development-indicators.

B. Geospatial indicators

All data related to geospatial indicators are collected in GIS-readable formats (raster-based maps or geographically referenced information).

1. Administrative country data

Administrative areas and boundaries. Global Administrative Areas database (GADM), Year: 2012. Available from http://gadm.org/.

2. Socioeconomic data

Open source maps and data. European Commission Joint Research Centre (JRC), "Environmental Monitoring" web page. Data also include elevation and slope data as "distance to markets" maps. Available from https://ec.europa.eu/jrc/en/research-topic/environmental-monitoring?search.

Country and population data. Socioeconomic Data and Applications Center, SEDAC. Available from http://sedac.ciesin.columbia.edu/.

3. Hydrological basins, rivers and irrigation maps

The boundaries of the hydrological basins and irrigation-related maps are extracted from FAO AQUAMAPS global spatial database on water and agriculture. Available from http://www.fao.org/nr/water/aquamaps/.

Homogeneous European catchments data set at scale 1:1 million. Year: 2006. Available from EEA at www.eea.europa.eu/data-and-maps/data/.

4. Digital elevation

The CGIAR-CSI GeoPortal provides global SRTM 90m Digital Elevation Data, Year: 2003. Available from http://srtm.csi.cgiar.org/ and www.cgiar-csi.org/.

5. Land cover

Land cover data. FAO (land degradation assessment in drylands, land use system maps) and JRC (global land cover) databases. Available from www.fao.org/ and https://ec.europa.eu/jrc/, respectively.

Land cover classes. GLC2000 data set produced by JRC, Year: 2008–2000. Available from https://ec.europa.eu/jrc/.

6. Lakes and wetlands

Spatial information about wetlands, water bodies, rivers and other water-related land forms. 1:1 to 1:3 million resolution. The global lakes and wetlands database, World Wide Fund for Nature, Year: 2004. Available from https://www.worldwildlife.org/pages/global-lakes-and-wetlands-database.

7. Protected areas

Protected Planet Database on Protected Areas, Year: 2012. Available from http://protectedplanet.net/.

8. Agricultural production area

Agriculture indicators are based on the Global Agro-Ecological Zoning model (GAEZ) from the International Institute for Applied Systems Analysis (IIASA) and FAO. Available from http://www.fao.org/nr/gaez/en/ and www.gaez.iiasa.ac.at/.

9. Urban areas

30 arc-second land area grid. Global Rural-Urban Mapping Project (GRUMP), Socioeconomic Data and Applications Center (SEDAC), Year: 2000. See http://sedac.ciesin.columbia.edu/.

Night-time light. The Earth Observation Group of the National Geophysical Datacenter. Lights and combustion sources, Year: 2000. Available from http://ngdc.noaa.gov/eog/.

10. Water risks

AQUEDUCT GLOBAL MAPS 2.0, which includes 12 global indicators related to a water risk framework (physical risk quantity, physical risk quality, regulatory and reputational risk), Year: 2008. Available from http://www.wri.org/publication/aqueduct-global-maps-20.

11. Forest change

Global Forest Change 2000–2013 database,[a] available from University of Maryland, Department of Geographical Sciences at http://earthenginepartners.appspot.com/science-2013-global-forest/download_v1.1.html.

12. Further sources

Other sources for free online geographic information and tools include, among many others, the GeoNetwork — Open Source (http://geonetwork-opensource.org/); the National Aeronautics and Space Administration (NASA) Earth Observing Data and Information System (EOSDIS) (https://earthdata.nasa.gov/); the NASA Prediction of Worldwide Energy Resource (https://earthdata.nasa.gov/); DIVA-GIS (http://www.diva-gis.org/Data); and Natural Earth (http://www.naturalearthdata.com/).

[a] See M. C. Hansen and others. High-Resolution Global Maps of 21st-Century Forest Cover Change. *Science*, vol. 342, No. 6160 (November 2013).

Annex II

Structure of the nexus assessment workshops

First workshop at the basin level

1. Introduction of the nexus and relevant explicatory examples (by the analysts).
2. Distribution of the opinion-based questionnaire.
3. Introduction to the key sectors, their main characteristics and issues by selected speakers.
4. Presentation of national sectoral policies by relevant authorities, as well as relevant national strategies and targets that may affect the basin.
5. Focus on the basin. Discussion on possible future development of the basin (river basin or aquifer management plan, infrastructure plans, sectoral targets, policy priorities etc.).
6. Illustration of possible interlinkages and nexus conditions. Explanation of the working group sessions.
7. First working group session on intersectoral mapping. Stakeholders are divided according to their area of expertise or work (land, water, energy, ecosystems). Each group identifies the most important interlinkages (impacts and trade-offs) associated with its component.
8. Joint prioritization of the key interlinkages to be considered in the assessment.
9. Presentation of official data on climate change and, if available, the predicted impact on the basin.
10. Second working group session on future dimensions. Participants are divided into mixed groups to define a few relevant scenarios and discuss how the key interlinkages will change under those scenarios.
11. Discussion on synergetic actions for the identified nexus conditions, by means of measures, policies, coordination arrangements and techno-economic solutions. Reflection on the transboundary dimension. Discussion on the benefits and limitations. Identification of who/which actors could advance the actions.
12. Discussion on indicators and sources available.
13. Presentation (by analysts) of some key findings or results from the workshop and the preparatory work, in the form of nexus graphs and storylines that will be analysed further and included in the basin assessment.
14. Presentation of next steps in the assessment.

Second workshop (for review of a draft nexus assessment report)

1. Presentation of findings and solutions.
2. Discussion on how the findings and solutions relate to policies or programmes in the countries and what could be done to address the identified intersectoral issues.

Annex III

Template for presentations by national representatives

National development plans and sectoral goals in the river basin

1. State → Basin

National targets and goals to be achieved:

(a) Food security;

(b) Energy security;

(c) Water security.

National policies and action plans for:

(a) Poverty alleviation;

(b) Environmental protection;

(c) Climate mitigation and adaptation;

2. Basin → State

List of key sectors in the basin (such sectors have to be key from the country's perspective, in the context of the basin). For example:

(a) Large-scale plantation of a certain crop (agriculture);

(b) Extractive industry.

List of sectors that could play a bigger role in the economy of the basin (high potential from the country's perspective). For example:

(a) Wind power production;

(b) Tourism.

3. Regional development programmes involving the key sectors in the basin

4. Implementation measures (for instance, incentives or other economic benefits to promote specific sectors)

General notes:

(a) Wherever possible, refer to quantitative and/or spatial information (e.g., irrigated land expansion: X number of hectares);

(b) Include a list of sources (policy, documents, website pages) to which the presentation refers.

Annex IV

Guide to the governance analysis

1. The governance analysis of a nexus assessment looks at the legislative, institutional and policy framework of the basin, the countries and the region by analysing:

(a) The institutional structure of water, energy, agriculture and ecosystems at the local, national, basin, transboundary and regional levels;

(b) The legislative framework;

(c) Measures and policy instruments to implement sectoral strategies at the national level;

(d) Economic instruments;

(e) The level of coordination and coherence among sectors and countries.

2. The governance analysis will help address the following questions:

(a) Where does the institutional framework lack coherence (e.g., gaps or overlaps of responsibilities, diverging objectives)?;

(b) What are the potentially conflicting objectives of sectoral policies, including shortcomings in the regulatory basis, administrative practice and the administrative philosophy that may present obstacles to the resolution of such conflicts?;

(c) Does the implementation of measures and regulations have the desired effect from a sectoral point of view? Does a nexus (intersectoral) point of view highlight the need to change them or to better coordinate them?;

(d) What opportunities are there for administrative cooperation, dispute resolution, expert input, the participation of stakeholders, etc.?;

(e) What is the scope of transboundary cooperation in relation to resource uses in the basin, and what aspects may hinder it? Can transboundary cooperation help to address the issues identified and, if so, how?

3. While governance analyses commonly also highlight the importance of political differences and power asymmetries, these factors were not specifically considered in the nexus assessment.

4. The questions set out in the following sections are meant to help the analyst in undertaking a governance analysis. In order to evaluate measures — from their coherence at an institutional level to their actual implementation — the questions are divided into four groups: institutions; sectors and policies; implementation (including economic instruments and legislation); and incentives and safety nets.

Institutions

5. When looking at institutions, it will be useful to ask:

(a) What are the institutions at the local, national, basin, transboundary and regional level governing the use of water, energy and land resources?;

(b) Which institutions protect the ecosystems and the functioning of the services they provide?;

(c) What type of institution(s) are there?;

(d) Are their mandates coherent (e.g., for a utility, to supply; for regulators, to establish prices and uses; separation of regulatory and operational functions, etc.)?;

(e) Is there coordination or conflict between institutions — within a sector, between sectors, or between the national and local or the national and regional levels?;

(f) Are there institutional arrangements in place to support intersectoral dialogue/cooperation?;

(g) Are there mechanisms in place to solve conflicts related to suboptimal resource allocation?

Sectors and policies

6. For sectors and policies, the following should be considered:

(a) What are the sectoral plans at the local, national, basin, transboundary and regional level for?:

(i) General: priorities for economic developments and (if applicable) reduce poverty;

(ii) Energy production and distribution (also for export);

(iii) Greenhouse gas mitigation and adaptation;

(iv) Water supply, sanitation and wastewater treatment facilities;

(v) Agriculture, irrigation plans, significant shifts to new crops or agro-industry type (also for export);

(vi) Ecosystems protection and support (including flood protection);

(vii) Expected/planned economic development in the region (including tourism);

(b) What are the sectors prioritized in policy?;

(c) Is there integrated planning (centralized/decentralized)? If too decentralized, how are significant plans taken into account in the activities of municipalities (coherence)? If too centralized, how can optimization be achieved locally?

Implementation (including economic instruments and legislation)

7. It is important to differentiate between countries in which a market economy is predominant and where State regulation is the main engine for change. In both cases, legislation is important although its extent may differ, but in the former case the application and relative significance of economic instruments is typically greater. The role of the market and economic instruments in the allocation of resources in particular is more prominent in market economies. So some important questions to ask are:

(a) What are the main incentives, regulations/legal requirements and standards aiming at protecting the environment?;

(b) Is the legal basis adequate (e.g., ownership of resources, users rights, uses)?;

(c) Pricing of energy and water. What are the market or allocation rules behind the pricing of these resources? How does this vary from sector to sector?;

(d) Allocation:

(i) How is land allocated? Are there many small farmers or large plantations? Are they formal or informal?;

(ii) How is water allocated to the different sectors? In particular, does the agricultural sector and/or the energy sector particularly benefit from national policies?;

(e) Are environmental assets related to the basin valued as economically significant? How is that value translated into policy?;

(f) Are the economic sectors (resource users) simply in conflict with environmental protection actors or there is some kind of collaboration (e.g., eco-tourism or bio-agriculture)? If yes, at which level?;

(g) With regard to the energy sector, is there specific legislation governing water/ land uses by the energy sector (e.g., environmental flows, legislation on chemical/thermal pollution, environmental impact assessment requirements for the installation of renewables)?;

(h) What regulations are there on resources use: water (treatment requirements, discharges, etc.), energy (efficiency), land (allotments, deforestation, etc.)?

Incentives (to reduce impact and improve efficiency) and safety nets

8. When analysing measures and instruments, it is important to include the point of view of the farmer (or cooperative, etc.), water and energy utilities, the private sector (e.g., industry). To this end, it will be useful to ask:

(a) How are the above-mentioned actors governed, and what are the incentives for them to efficiently use resources and limit their impact? Do existing incentives work?;

(b) Are inputs (resources) regulated? Are outputs regulated and, if so, how?;

(c) How are economic activities supported (e.g., reduced taxation, subsidy, rations and fixed tariffs)? What institution oversees the implementation of the incentives? In particular:

(i) Subsidies to agriculture. How much does water cost to farmers and how is it provided (e.g., fixed connection or ration)? Are fertilizers, machinery, etc., accessible at convenient prices? Are the incentives directed at specific crops (is growing certain crops more convenient than growing others)?;

(i) Are there significant subsidies for one energy source over another, that cause the poorest to overuse one resource or that avoid the exploitation of other resources?;

(d) What are the mechanisms to ensure that tariffs increases, new technologies and new regulations do not hit the poorest shares of population?