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Draft assessment of the water-food-energy-ecosystems nexus in the Isonzo/Soča River Basin

Assessment of the water-food-energy-ecosystems nexus in the Isonzo/Soča River Basin*

Prepared by the secretariat with the Royal Institute of Technology

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 for the seventh session of the Meeting of the Parties (see ECE/MP.WAT/37, para. 38 (i)).

The present document contains the scoping-level nexus assessment of the Isonzo/Soča River Basin with a focus on the downstream part of the basin. The document is the result of an assessment process carried out according to the methodology described in publication ECE/MP.WAT/46, developed on the basis of a desk study of relevant documentation, an assessment workshop (Gorizia, Italy; 26-27 May 2015), as well as inputs from local experts and officials of Italy. Updates in the process were reported at the meetings of the Task Force. Findings were discussed at a stakeholder consultation workshop organized by the Italian Ministry for the Environment, Land and Sea in Venice on 12 October 2015, and a draft of the assessment was circulated for review and comments to the authorities of the riparian countries. Slovenia informed in the process that, due to limited human capacity, it could not be involved during this phase but indicated openness to participate in a continuation of the process in 2016. The document is therefore based on a

* This present document is being issued without formal editing.

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desk study and information provided by Italy.

The document was prepared by the secretariat in cooperation with the Royal Institute of Technology (Sweden) and a consultant. The main interlinkages and possible solutions identified were presented to the tenth meeting of the Working Group on Integrated Water Resources Management (Geneva, 24–25 June 2015), which took note of the preliminary findings, invited Italy and Slovenia as well as other concerned stakeholders to provide the necessary input for completion of the assessment and entrusted the secretariat to submit the draft assessment to the Meeting of the Parties.

The Meeting of the Parties may wish to:

(a) Take note of the findings of the scoping-level nexus assessment of the Isonzo/Soča River Basin;

(b) Invite Italy and Slovenia to continue the dialogue to explore whether on the basis of this scoping level assessment, a second phase of the assessment with mutually agreed specific objectives could be carried out from 2016 to 2017.

(c) Thank Italy for support to the nexus assessment and for advocating a nexus approach in the framework of the Alpine Convention.

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I. Introduction

A. Aim, objectives and scope

1. The water-food-energy-ecosystems nexus assessment in the Isonzo/Soča River Basin, shared by Italy and Slovenia, is a scoping-level exercise, contributing to the assessment of the water-food-energy-ecosystems nexus in transboundary river basins carried out in framework of the 2013-2015 programme of work of the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention).

2. So far, three river basins have been assessed using the same methodology, namely 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.

3. These basin assessments in general have the objective of fostering transboundary cooperation by:

(a) Identifying intersectoral synergies that could be further explored and utilized;

(b) Determining policy measures and actions that could alleviate tensions or conflicts related to the multiple uses of and need for common resources.

4. The nexus assessment also aims to:

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

(b) Build capacity to assess and address intersectoral impacts.

5. So in brief, the assessment supports the transition towards a green economy and improving sustainability in resource management. In each case, the focus adapts to the situation in each basin and to the riparian Countries' needs but focuses on identifying areas where cross-sectoral coordination and transboundary cooperation are needed or would be beneficial in the basin area. This is done by investigating – jointly with local officials - interlinkages across sectors, discussing their nature and implications.

B. Assessment process

6. The basin selection for the assessment had as its basis a call for proposals by the Parties to the Convention (November 2012). Italy proposed an Alpine basin to be assessed for the nexus and, after a consultation process has been developed and some proposals have been presented, the Isonzo/Soča was deemed as the most meaningful, following Italy's consultation of Slovenia. The nexus assessment of the Isonzo/Soča and its possible scoping was discussed between Italy and Slovenia on several occasions.[1] A consultation meeting between Italian and Slovenian authorities (Ministry for the Environment, Land and Sea of Italy and the Ministry of the Environment and Spatial Planning of Slovenia) in Ljubljana on 12 November 2014[2] led to exchanges between the riparian countries on the most appropriate scope and possible modalities. During the XIII Alpine Conference (Conference

[1] The nexus assessment has been discussed in the bilateral Italian-Slovenian hydro-economic Commission (Miren, November 2014), as well as in other informal bilateral meetings.

[2] The UNECE secretariat and the Royal Institute of Technology participated the meeting and provided information.

of the Parties to the Alpine Convention), the concluding event of the in-turn Italian Presidency, held in Turin on 20-21 November 2014, intention of Italy and Slovenia to cooperate on the nexus assessment of the Isonzo/Soča was announced as a statement.

7. The Isonzo/Soča nexus assessment is a joint effort by analysts from the United Nations Economic Commission for Europe (UNECE), the Royal Institute of Technology (KTH, Stockholm) as international experts together with local experts and national officials. Italian officials, other key actors and experts provided input to the present document. A participatory workshop was held in Gorizia, Italy on 26-27 May 2015, involving Italian representatives of the Ministry for the Environment, Land and Sea, civil society, academia and experts from the Friuli Venezia Giulia Region (FVG), the Basin Authority (AdBve), the land reclamation consortium (Consorzio di Bonifica della Pianura Isontina), the Municipality of Gorizia and the European Grouping of Territorial Cooperation (GECT GO). Slovenian authorities were invited to participate but neither provided information nor participated in the workshop. Therefore, in the first stage of the assessment, intersectoral issues were discussed with a particular focus on the Italian side of the basin. Information and conclusions on the transboundary intersectoral issues and interlinkages could be further developed and detailed, should also Slovenian authorities participate in a continuation of the activities in 2016.

8. The information used for this scoping-level assessment document was gathered through (i) the workshop (ii) a factual questionnaire with a consolidated reply by Italian experts and (iii) a desk study on natural resources and socio-economy in the basin. A preliminary list of identified possible beneficial actions ("solutions") is presented as a basis for discussion. The information in the present document could set the basis for a proposed second phase of the assessment involving also Slovenian authorities and experts, provided that follow up is agreeable to both countries. The Slovenian authorities have indicated a possibility to participate in a continuation of the process in 2016, subject to internal consultations and to an agreement reached between the riparian countries on the scope. This participation would extend the inputs to the process and increase the added value of the assessment.

C. Basin overview

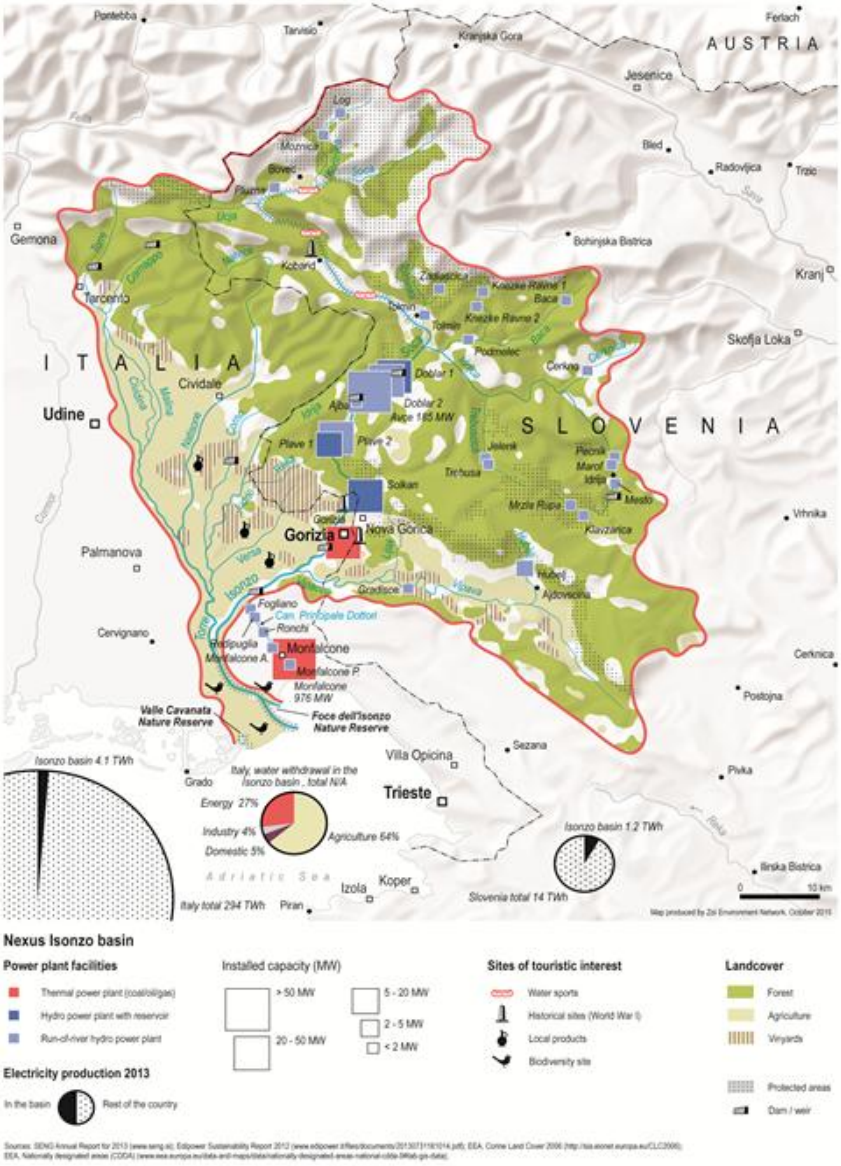
Geography and river characteristics

9. The Isonzo/Soča is a 140 km long (40 km in Italy downstream and 100 km in Slovenia upstream) alpine river that flows from north-east to south-west.[3] The surface area of the basin is about 3400 km^2. One third of its basin is located in Italy (about 1.150 km^2) and two-thirds in Slovenia (about 2.250 km^2).[4] Before the Second World War, the whole catchment area was Italian territory. The upper Isonzo catchment became Yugoslavia in 1954, while the piedmont and the coastal plain remained Italian. Because of its rich history and nature, the Isonzo/Soča River has a high cultural value for both countries.

[3] United Nations Economic Commission for Europe (UNECE*), Second Assessment of transboundary rivers, lakes and groundwaters*. Geneva, 2011.

[4] CAMIS. Storie d'Isonzo. Contenuti selezionati del Progetto / Zgodbe Soče, Izbrane vsebine Projecta (2013).

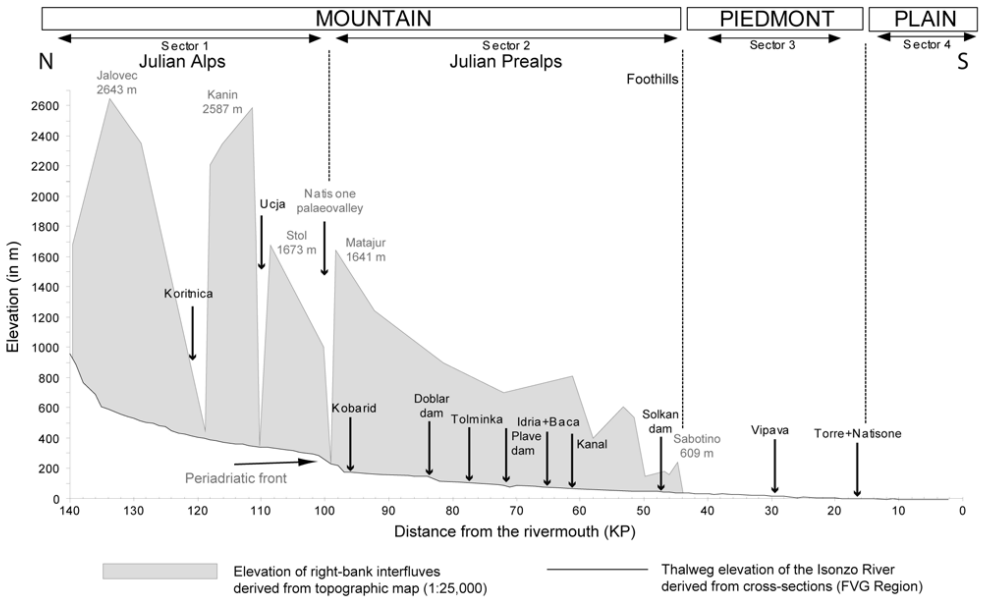
Figure 1
Map of the Isonzo/Soča River Basin



10. The source of the river is located in the Trenta Valley at 935 m a.s.l. of altitude in the Julian Alps, North-Western Slovenia, while its mouth belongs to the Panzano Gulf, Northern Adriatic Sea in North-Eastern Italy. The average elevation of the basin is about 600 m a.s.l. Its catchment area (3,383 km^2) consists of mid-altitude mountains (70%), a piedmont (22%), and a coastal plain (8%) (see figure 2) with a slope of 2% in the mountain area, 0.6% in the piedmont and 0.2% in the plain.[5]

[5] Alberto Cisotto, *The Isonzo/Soča River Basin – Eastern Alps District*. Budapest, Hungary 8-10 February 2011. Workshop on Transboundary Water Cooperation in Central and Western Europe.

Figure 2
Longitudinal profile of the Isonzo/Soča River[6]



Note: Interfluve is the region of land between two rivers that are in the same drainage system. *Thalweg* is the line of lowest elevation within a watercourse.

11. The main transboundary tributaries are the Natisone/Natiža (60 km, 261.6 km^2) and the Vipacco/Vipava (49 km, 600 km^2). The Natisone/Natiža is a tributaries of Torre (47km, 1 060 km^2), Malina (160,3 km^2) – formed in Italy – and the transboundary Judrio/Idrija (50 km, 280 km^2). Vipacco/Vipava's tributaries are the Hubelj and the Liljak – formed in Slovenia. Other tributaries include the Koritnica, Ucja, Tolminka and Idrijca (60 km, 642 km^2) with Cerknica, Trebušćica and Baca, and they are all on the Slovenian side.[7] The two largest lakes near the basin are Doberdò and Pietrarossa.[8] On the Italian side, the overall length of the Isonzo and all the tributaries is 525.5 km. Out of 70 water bodies on the Italian side, two are artificial and 16 are strongly modified.[9]

12. The area is influenced by the Mediterranean climate, although high mountains have colder and more humid climate. Precipitation ranges from 2,400-3,100 mm in the Julian Alps, 2,000-2,500 mm in the Julian Prealps, 1,400-1,800 mm in the piedmont hills and

[6] Isabelle Siché and Gilles Arnaud-Fassetta, Anthropogenic activities since the end of the Little Ice Age: a critical factor driving fluvial changes on the Isonzo River (Italy, Slovenia). Méditerranée [Online], 122 | 2014, Online since 19 June 2016, connection on 09 September 2015. URL : mediterranee.revues.org/7253

[7] European Commission, *Italy River Basin Management Plan* (Italy RBMP). Brussels: European Commission, 2012; Autorita' di bacino dei fiumi Isonzo, Tagliamento, Livenza, Piave, Brenta-Bacchiglione (Autorita' di bacino), *Progetto di piano stralcio per l'assetto idrogeologico dei bacini idrografici dei fiumi Isonzo, Tagliamento, Piave e Brenta-Bacchiglione*. Venezia, 2007; Andrea Bianchini and Francesco Baruffi, *The Isonzo/Soča River Basin. Status and perspective on the possible Alpine river basin to be assessed*. Geneva, September 8th 2014; Paola Albrecht, *Il fiume Isonzo: descrizione fisica del Bacino dell'Isonzo e dei suoi affluenti*. Natura ed ecologia, vol. 10, 35-48. 1998.

[8] United Nations Economic Commission for Europe (UNECE*), Second Assessment of transboundary rivers, lakes and groundwaters*. Geneva, 2011.

[9] Alpi Orientali, Piano di Gestione 2015-2021. Direttiva Quadro Acque 2000/60/CE. Venezia – Trento, 2014.

from 1,000-1,400 mm in the plain.[10] Rainfall regimes, with a dry season in February and July and two precipitation maxima in fall and spring, determine the hydrological regime of the Isonzo River.[11]

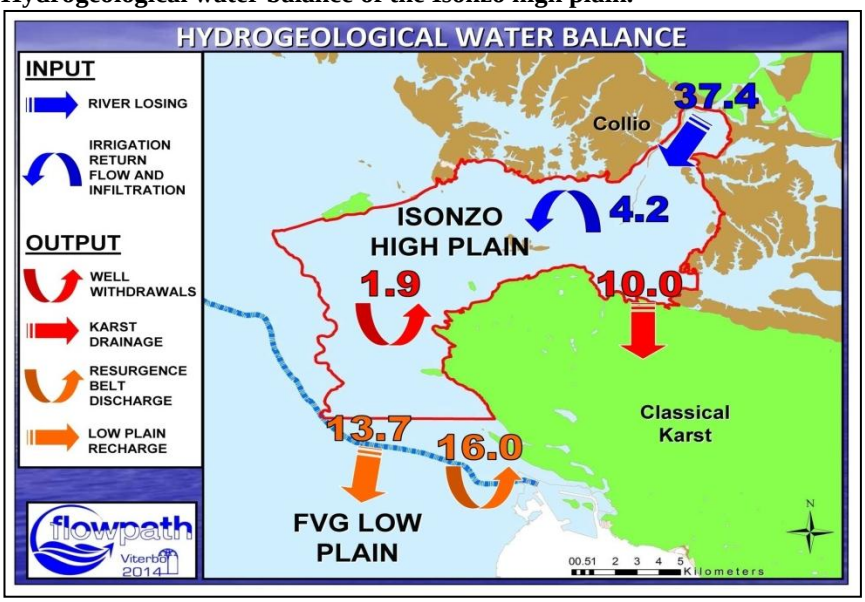
13. The average discharge of the river (Q_{av}) is 172 m^3/s as measured at Pieris gauging station. The maximum discharge (Q_{max}) was documented in 1925-1953 to be 4,400 m^3/s, and the minimum (Q_{min}) 12.1 m^3/s on 3 August, 1904. Currently, the discharge of the Isonzo/Soča also depends on the opening or closing of the many dams built along its course, particularly in Slovenia.[12]

14. The hydrological water balance of the Isonzo/Soča Basin allows to conclude the following indicators for the Italian side of the basin:[13]

- Total renewable surface water = $5{,}4\times10^9$ m^3/yr.

Total renewable groundwater = $1{,}33\times10^9$ m^3/yr.•

Figure 3
Hydrogeological water balance of the Isonzo high plain.[14]



15. The following transboundary aquifers in the basin have been reported: Catena Paleocarnica orientale, Alpi Giulie e Fascia Prealpina nord orientale, Fascia Prealpina sud orientale, Carso classico isontino e triestino, Canin, Alta pianura isontina, Rabeljski Rudnik

[10] Alberto Cisotto, *The Isonzo/Soča River Basin – Eastern Alps District*. Budapest, Hungary 8-10 February 2011. Workshop on Transboundary Water Cooperation in Central and Western Europe.

[11] Isabelle Siché and Gilles Arnaud‑Fassetta, Anthropogenic activities since the end of the Little Ice Age: a critical factor driving fluvial changes on the Isonzo River (Italy, Slovenia). Méditerranée [Online], 122 | 2014, Online since 19 June 2016, connection on 09 September 2015. URL : mediterranee.revues.org/7253

[12] Alberto Cisotto, *The Isonzo/Soča River Basin – Eastern Alps District*. Budapest, Hungary 8-10 February 2011. Workshop on Transboundary Water Cooperation in Central and Western Europe.

[13] The value for total renewable surface water resources is calculated using data of annual average flow of Isonzo River and Vipacco River (source: Water protection Plan of Regione Friuli Venezia Giulia). The value for total renewable groundwater resources is calculated as the sum of groundwater produced internally and accounted groundwater inflow

[14] Zini L., Calligaris C., Treu F., Iervolino D., Lippi F., 2011 – Groundwater resources of Friuli Venezia giulia Region: susteneability of the current use. Edizioni EUT, 89 pp., Trieste, 9-788883-033148

Aquifer, Kobariški Stol Aquifer, Osp-Boljunec Groundwater Body, Brestovica Aquifer, Vrtojbensko Polje Aquifer. All of these are unconfined, and are in carbonates (different types) and/or karstic limestone.[15] There are also porous system aquifer (clastic alluvial - gravel and sands).[16]

16. In the basin, land cover is distributed as follows: forests 49%, cropland 44%, urban 6% and waterbodies 0,7%.[17] Land use in the basin changed in the past century, following the shift from a traditional agro-forestry-pastoral system. Meadows characterise the valley bottoms and the alluvial fans are equipped with retaining walls and used for pastoral activities.

17. In the past century, Slovenia implemented a policy of slope reforestation in the middle basin to limit soil erosion.[18] In Italy, while forest area progressively decreased in the plain portion of the Isonzo/Soča Basin due to the enlarging of crop cultivations, in the mountainous areas it is increasing because there is a progressively abandonment of traditional activities (grazing and mowing). These abandoned lands are poorly managed and are progressively transforming into shrub forests.[19]

18. The surface area of wetlands on the contrary has significantly reduced. Between 1925 and 1935, land reclamation projects and artificial embankments (for enlarging agricultural and urban areas) lead to a significant reduction of flood plain area in the Italian side.[20] Nowadays, the main wetland in the basin is the Preval's swamp.[21]

19. The basin's rivers are important ecological corridors for wildlife species, which populate the basin and in particular the biodiversity spot of the lagoon. Several species in the FVG region are endangered and not all habitats are officially protected (e.g. Crex crex in the Gran Monte).[22] Invasive alien species (IAS) are an issue, causing the major loss of plant biodiversity in the basin.[23]

20. The Slovenian Ministry of the Environment and Spatial Planning reported in 2011 on the quality of their rivers and Soča is estimated to be of "very good" quality at their measuring stations. The Vipava River is the most polluted, with some nutrient species exceeding the allowed limits due to agricultural activities.[24] In the Italian side, the ecological state of water bodies is assessed as good overall but many of them are not monitored yet.[25] High quality of water and abundant biotic presence are reported in the medium-upper Soča/Isonzo and in the Natisone-Torre, while intensive agricultural uses in

[15] United Nations Economic Commission for Europe (UNECE*), Second Assessment of transboundary rivers, lakes and groundwaters*. Geneva, 2011.

[16] Alberto Cisotto, *The Isonzo/Soča River Basin – Eastern Alps District*. Budapest, Hungary 8-10 February 2011. Workshop on Transboundary Water Cooperation in Central and Western Europe.

[17] *Ibid.*

[18] Isabelle Siché and Gilles Arnaud‑Fassetta, Anthropogenic activities since the end of the Little Ice Age: a critical factor driving fluvial changes on the Isonzo River (Italy, Slovenia). Méditerranée [Online], 122 | 2014, Online since 19 June 2016, connection on 09 September 2015. URL : mediterranee.revues.org/7253

[19] Response to the factual questionnaire by Italy. 2015

[20] Response to the factual questionnaire by Italy. 2015

[21] Response to the factual questionnaire by Italy. 2015

[22] Response to the factual questionnaire by Italy. 2015

[23] Response to the factual questionnaire by Italy. 2015

[24] Agencija Republike Slovenije za okolje, Ocena Stanja Rek v Sloveniji v Letu 2011. www.arso.gov.si/en.

[25] Agenzia Regionale per la Protezione dell'Ambiente del Friuli Venezia Giulia (ARPA FVG). Presentation at the Water-Food-Energy-Ecosystem Nexus In the Isonzo/ Soča River Basin. Gorizia, 26-27 May 2015.

the valley of Vipacco and in the Friuli plain (middle-lower Natisone-Torre and lower course of Isonzo) impact water quality locally. The chemical status of groundwater bodies in the Italian side is also monitored. In a recent report of by the Regional Environmental Protection Agency (ARPA) the chemical status of 'good' and 'not-good' are assigned to each groundwater body. Where the chemical status is 'not good' – mainly in the plain areas - this is mainly due to chlorinated solvents, nitrates and fertilizers.

21. Finally, there are issues associated with mercury contamination. A doctoral thesis from University of Trieste concluded that contamination of the Grado lagoon from the Isonzo River – specifically from the old Idrijca mercury mine, now closed – is continuous and its effects, as well as opportunities to reduce its spreading, should be further studied.[26],[27]

Socio-economic relevance of the basin

22. The basin area counts 255,630 inhabitants.[28] Using remote Geographic Information System and Remote Sensing, population in the basin is estimated to be around 280,000, with 180,000[29] in Italy and 100,000 in Slovenia.[30]

23. In Slovenia, the river runs past the towns of Bovec (1,612), Kobarid, Tolmin (3,737), Kanal ob Soči, Idrija (5,878), Nova Gorica (13,178), and in the Vipava valley Ajdovščina (6,373) and Vipava (1,566). In Italy, the biggest city is Gorizia (35,980); other large settlements are Cormons (7,698), Cividale del Friuli (11,615), Tarcento (9,111). The Isonzo/Soča enters the Adriatic Sea close to the town of Monfalcone. The two Italian city-provinces of Udine and Trieste are not far from the basin area.

24. Water from the basin is withdrawn for energy, industrial and agricultural uses.[31] In the Slovenian part of the basin the main economic activities are related to hydroelectric production as well as tourism. In the Italian side of the basin, hydropower is the main water user, followed by irrigation, recreation/fishing and other uses.[32]

25. Agriculture is an important sector in the basin. In the Gorizia Province (Italian side), the overall agricultural surface used is equal to 14,000 hectares, almost exclusively located in the plain areas of the Isonzo valley, stretching from the sea to the foot of the Collio and Carso hills. Out of these, 1,000 hectares are included in the irrigation area managed by the Consorzio di Bonifica Pianura Isontina:

[26] Alessando Aquavita, Mobilità delle Specie Mercurifere in Condizioni Naturali e Perturbate in Ambiente Lagunare, Università degli Studi di Trieste, Anno Accademico 2009-2010.

[27] In 1996, mining at Idrija ceased, however the analysis does not show any subsequent decreasing trend in terms of Hg flux, which implies the system retains some "memory" of Hg contamination. A decrease in Hg inputs into the nearby Gulf of Trieste and the Lagoon seems unlikely in the short terms. A preliminary estimate of the total Hg "trapped" in the lagoon's sediments amounted to 251 t. Such a quantity, along with the complexity of the lagoon ecosystem, suggests that a complete removal of the sediments from the lagoon is for now unfeasible, both economically and environmentally.

[28] CAMIS. Storie d'Isonzo. Contenuti selezionati del Progetto CAMIS. / Zgodbe Soče, Izbrane vsebine Projecta (2013)

[29] 170 809 according to an estimation by the Eastern Alps District with data from ISTAT 2011, Italian census of population.

[30] The LandScan™ Dataset. 2011.

[31] United Nations Economic Commission for Europe (UNECE*), Second Assessment of transboundary rivers, lakes and groundwaters*. Geneva, 2011.

[32] Francesco Baruffi, AdB. *Hydroelectric uses in the Soča---Isonzo river*. Presentation at the Water-Food-Energy-Ecosystem Nexus In the Isonzo/ Soča River Basin. Gorizia, 26-27 May 2015.

(a) Approximately 55% of the agricultural surface is covered with crops for human consumption (barley, wheat) and animal consumption (corn, soy bean, sunflower, rape, fodder);

(b) There is a significant production of wine (Collio hills), distillates, fruits (apples, pears, peaches, kiwis, cherries), and a small quantity of oil, all amounting to 27%;

(c) Another 17% is occupied by woods and pastures, especially in the hills;

(d) The last 1% is occupied by greenhouses and horticultural crops.

26. Agriculture plays a key role in the economy of the Isonzo area, with over 1,250 farms and over 2,000 workers, accounting for 7% of the workforce in the province, for an estimated value added of over 80 million euro.

27. In particular here the main quality products of the basin:

- wines with controlled designation of origin[33]
- honey[34]
- Collio cherries
- chicory "rosa di Gorizia"[35]

28. Moreover, in the Italian part of the basin the agricultural sector (with particular reference to the production of quality wines) and energy production (hydropower and thermal power) is becoming strategic in order to promote a recovery from the economic crisis that started in 2008, as shown by the constantly positive trend of economic and occupational indicators.[36]

29. In the Vipava Valley (Slovenian side) agricultural products include wine, fruit (peaches, apricots, cherries) and vegetables. The food processing industry is present in Ajdovščina (fruit juices) and Nova Gorica (meat products). The agricultural production potential of Vipava Valley is not as exploited as the plain on the Italian side of the border. In upland areas, dairy and beef cattle farming almost exclusively prevail with sheep farming slowly re-emerging in some areas.

30. Slovenia evaluates every year the suitability of its rivers for fish. According to their report from 2013, the Vipava upstream got the worst results, as the concentration of nitrites and ammonia is above favourable values for fish settlements. The Soča is home to the endangered marble trout *(Salmo marmoratus)*, which lives in the upper course of the river. This unique trout species survives in the tributaries but it is under threat by non-indigenous trout species.[37]

31. River-related tourism is well developed in the Slovenian part of the basin. This is oriented towards sport (rafting and other water sports in particular), due to the mountainous characteristics of the river up to the Solkan dam, at the border with Italy. On the Italian side

[33] For indication and characteristics see:
www.agraria.org/vini/collio-doc.htm;
www.collio.it/it/i-vini/
www.agraria.org/vini/friuli-isonzo-doc.htm
www.agraria.org/vini/friuli-colli-orientali-doc.htm
www.colliofriulano.it/

[34] For indication and characteristics see: : www.mielisenzaconfini.it/

[35] Under 'slowfood' protection.

[36] Factual questionnaire compiled by Italy. 2015.

[37] Balkan Trout Restoration Group (BTRG), Marble trout (*Salmo marmoratus*). Accessed March 1, 2015. Available from www.balkan-trout.com/studied_taxa_7_marble_trout.htm (2014).

the river becomes flat, not allowing for the same type of water sports apart from kayaking. Tourism here focuses more on vineyards, local products and evolve around some important historical sites such as Cividale del Friuli. In the Slovenian side, the Soča valley is among the top touristic destinations in the Country.[38]

32. The section of the river with rapids in the Italian territory downstream from the Solkan dam to the confluence with the river Pevmica, where the flow is not impounded, is among the most picturesque sections. Just downstream of the confluence of the Pevmica the river becomes flat until the Straccis dam. The entire stretch from the Solkan dam to the mouth of river Pevmica is suitable to all kinds of water sports, including rafting[39] and kayaking). Along the river there are small gravel islands along this stretch and very wide sand beaches (the beaches of the city of Gorizia). This stretch is also rich in historical remains (ruins of bridges from the 1800s and monuments of the 12 battles of the Isonzo).

33. Finally, the stretch of the Isonzo on the Italian side straddling the border holds the role of a potential tourist hub for discovering the millennial historical heritage of the city of Gorizia, including all First World War sites of great historical value[40] and for visiting Collio and Carso.

34. The basin is rich in protected areas, especially in the Slovenian part of the Basin. Triglavski national park, the most important national park in the area. The entire River Soča on the Slovenian side is protected as Natural Monument. The Idrijca and Vipava rivers with their tributaries are not included in the Soča Natural Monument but they are protected under different categories as separate entities. The mouth of the Isonzo is also protected as a Regional Nature Reserve, it is a Natura 2000 site and it is pending to be recognized as a "wetland of international importance". The area is important for breeding and passage birds, with up to 10,000 occurring during migration periods. Human activities in these areas include commercial fish farming and tourism.[41]

35. Industrial activities include mainly steel plants, paper mill, mechanical sector and wood furniture sector.[42]

36. The main energy production in the Slovenian side of the basin consists of hydropower, with high capacities installed (the total large hydropower installed is 322 MW). In Italy, large hydropower is less developed. The dams of Sagrado, Straccis and Piedimonte (total capacity of 5.8 MW) are owned by industrial companies and are not connected to the grid. Small hydropower is quite developed, mainly in combination with irrigation schemes, with most installations connected to the grid (total capacity 1.5 MW). Other than that, the following thermal plants use water for cooling from the basin: Monfalcone Coal Power Plant, Edison Torviscosa CCGT (Combined Cycle Gas Turbine) Power Plant and Servola CCGT Power Plant, the last two fuelled by natural gas. Table 1 shows the contribution of hydropower and thermal power production in the basin to overall national productions.

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[38] See for example touristic information at www.slovenia.info/en.

[39] For rafting, for some thirty years, a traditional transboundary regatta with a high number of participants, has been organized.

[40] See also the 'Walk of Peace' in Slovenia at page 151 of: Permanent Secretariat of the Alpine Convention. *Sustainable Rural Development and Innovation*. Report on the State of the Alps. 2011. Available at www.alpconv.org/en/AlpineKnowledge/RSA/sustainable/Documents/20110906RSA3_longversion_en.pdf.

[41] RAMSAR Sites. Accessed March 1, 2015. Available from www.ramsar.org/sites-countries/the-ramsar-sites.

[42] Response to the factual questionnaire by Italy. 2015.

Table 1
Electricity production

Relevance of electricity production in the basin for riparian Countries[a]			
Total: HPP+TPP	to total net production	IT	2.9%
		SI	8.7%
HPP	to total hydroelectric production	IT	0.5%
		SI	32.9%
TPP	to total thermoelectric production	IT	4.0%
		SI	-

[a] Note that only power plants that are connected to the national grids were taken into account. Regarding thermal plants, the ones using water from the river were taken into account. Source: Chiara Mei, Politecnico di Torino and KTH Royal Institute of Technology. *The Water, Energy and Land linkages on the Isonzo-Soča river basin*. 2015.

37. Intensive cross-border co-operation exists around the cities of Gorizia, Nova Gorica, and Šempeter-Vrtojba in the framework of the European Grouping of Territorial Cooperation among the three towns (EGTC GO) especially in trade, transport and tourism. The basin hosts important transit roads, for example on the Italian-Slovenian border between Sant'Andrea and Vrtojba, the Italian territory hosts the Sdagin border terminal, where also lies one of the two rail crossings connecting Italy to the Balkans. The transboundary context of Gorizia and Nova Gorica also strongly influences the service activities in Goriška region, contributing to the fact that the region is the one with the lowest unemployment rate in Slovenia. Tourism here is distinctly geared towards casinos and related services and adapted to the needs of Italian visitors.

38. In terms of transboundary tourism, the two countries cooperate in many ways (see section ‘Basin level governance’). First of all, with regard to the basin, they share the Isonzo Transboundary Park - another pilot of the EGTC GO - located between the Solkan and the Straccis-Crs dams.

Administrative regions

39. The Italian part of the basin takes up smaller part of the Friuli-Venezia Giulia (FVG) autonomous region. The territory is further divided into two provinces, Udine upstream and Gorizia downstream, of which the second one takes up larger part of the Italian part of the Basin.

40. The Slovenian part of the basin is divided into five regions: Osrednjeslovenska, Gorenjska, Primorsko-notranjska (until 2015: Notranjsko-kraška), Goriška and Obalno-kraška. Goriška region takes up the largest part of the Soča basin; Osrednjoslovenska and Gorenjska regions' areas in the basin are negligible.

II. Describing the governance context

A. Basin level governance

41. **River Basin Management**. The Isonzo/Soča does not have a formal transboundary basin authority but there is presently good technical cooperation between Italy and Slovenia in coordinating their respective plans, which are prepared according to the requirements of the European Commission. The Permanent Italian-Slovenian Commission for Water Management was established by the Treaty of Osimo (1977) between Italy and Republic of Yugoslavia. This has the task of "studying all hydrological problems of common interest, proposing appropriate solutions, aiming to ensure the improvement of water and electricity supply in relation to international obligations assumed by the two Countries, and to analyze the regularization and the water exploitation for the production of electricity."[43] The first Italian-Slovenian Isonzo Common Management Plan is expected to be operational by the end of 2015. (Cisotto, 2011)

42. **Cooperative projects.** Several projects have been carried out with EU funds to develop cooperation between the countries. Relevant examples for this assessment are:

(a) SIMIS (2003-2007) - consisting in the creation of an integrated and coordinated monitoring system for the assessment of hydraulic and hydro-geological risks;[44]

(b) ASTIS (2007-2013) - aiming to develop guidelines for the Italian-Slovenian important problem in the management of transboundary waters in the basin;[45]

(c) CAMIS (2007-2013) - promoting coordination between the countries in terms of sustainable management of water resources in the basin;[46]

(d) GOTRAWAMA (2007-2013) - proposing guidelines for the development of a common integrated system for the sustainable management of transboundary surface and underground waters in Gorizia and Nova Gorica;[47]

(e) DISO and ISO (2000-2006) - promoting cross-border cooperation and sharing of best practices for urban wastewater collection and treatment;[48]

(f) TRUST (2009-2011) - analysing the impact of climate change on groundwater and exploring artificial groundwater recharge options for climate change adaptation.[49]

43. In addition, several cooperative projects exist in the basin region that aim at boosting tourism. Apart from the Isonzo Transboundary Park, relevant examples focus on rural tourism and joint promotion of typical product,[50] slow tourism itineraries,[51] landscapes and cycling paths across the border,[52] the Slovenian and Italian museums network[53] and the 'path of peace' of Pot Miru.[54]

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43 www.interno.gov.it
44 www.ita-slo.eu/map_eng/3
45 astis.ung.si
46 www.camisproject.eu/
47 www.gotrawama.eu/
48 www.ita-slo.eu/projects/projects_2000_2006/47
49 www.lifetrust.it/cms/
50 rural-pro.eu/
51 www.slow-tourism.net/contentsite/index.php?lang=en
52 www.ita-slo.eu/progetti/progetti_2007_2013/2014052209542679

44. **Cross-sectoral governance at basin level.** Inter-sectoral linkages across the border are only minimally understood and are normally reduced to water allocation trade-offs between energy production and agricultural needs.

B. Supra-basin level governance

45. **European Union (EU).** Both riparian countries are member States of the European Union. By obligation, they have to comply with the *acquis communautaire*, transposing the EU legislation and adopting the various directives, including the Water Framework Directive. On top of the well-established Energy Union, the EU invests significantly in developing a Common Agricultural Policy (CAP).

46. **UNECE region**. Italy and Slovenia are parties to the Espoo Convention on Transboundary EIA as well as to its SEA Protocol, the UNECE Water Convention and its Water and Health Protocol.

C. National level governance

47. **Multi-level governance.** In Slovenia, national-level institutions are in charge of developing and implementing strategies, laws and regulations. There are no regional level institutions but local governments have responsibilities in the implementation of policies related to management of natural resources and environmental protection. The situation is different in Italy, where each region, especially the autonomous ones like Friuli Venezia Giulia (FVG), have a significant degree of autonomy in self-government, legislation and administration.

48. The Isonzo, in Italy, is one of the five hydrological basins managed by the High-Adriatic River Basin Authority (ADBVE), which is part of the River Basin District of Eastern Alps. The Soča river, in Slovenia, is part of the High-Adriatic River Basin District.

49. **Green growth**. Both Italy and Slovenia recognize the potential of pursuing a 'green' economy and growth to take advantage of their rich natural capitals. For example in the touristic sector, Slovenia invested largely in eco-tourism in environmentally valuable regions (such as the Soča river), and Italy is promoting more and more local products and eno-gastronomic itineraries. A green growth perspective was explicitly adopted in the formulation of the Development Plan 2013-2020 of Slovenia and a multi-stakeholders dialogue on green economy was initiated in Italy in 2012 (Stati Generali della Green Economy), promoted by the Ministry of Environment, Land and Sea and the Ministry of Economic Development.

50. **Water governance**. A river basin management approach based on basin boundaries is well-established in Italy (efforts started before 2000), although challenges remain regarding the coordination of administrative units and basin authorities. This overlap of responsibilities cause sometimes a duplication of efforts in developing and implementing plans (for example, in Italy the Integrated Water Resource Management Plan and the Water Resource Protection Plan are separate documents,[55] which sometimes lack coherence). Uncertainties relative to the roles of private sector and public authorities in water management lead to Italy's water service provision overall is not comparing well with

[53] www.openmuseums.eu/
[54] www.potmiruviadipace.org/it/59/il-progetto
[55] See norms at www.isprambiente.gov.it/it/temi/acqua/gestione-delle-risorse-idriche-in-italia.

other EU countries (for example, water tariffs are in urgent need to be reformed to take into account real costs of operation).[56] However, the situation varies greatly from basin to basin.

51. River Basin level management is more recent in Slovenia and it is responsibility of the central government. Integrated Water Resource Management is in principle applied but more needs to be done, for example to address trade-offs between large water using sectors (first of all, energy) and ensure public participation in environmental impact assessment procedures.[57] Significant improvements are being made with regards to wastewater management in Slovenia, spurred by implementing the requirements of the Urban Waste Water Treatment (UWWT) Directive of the EU.

52. **Environmental governance**. To enhance environmental performance at local level, Italy has adopted a policy of a major devolution of legislative and administrative responsibilities to sub-national institutions. This has led to higher performances but also to more ambiguities over roles and responsibilities, leading to more inconsistencies with the application of EU directives.[58] Both countries are Parties to the Aarhus Convention, which establishes public participation and information in policy making related to the environment. Efforts are being made to mitigate emissions and to reduce the impact of transport sector which is the most problematic one in both countries.

53. **Energy governance**. The energy market has been liberalized about 15 years ago in both Slovenia and Italy. Renewable energies have been since then promoted in Italy with large investments resulting in high employment rates. Despite this, spending in research and development are low compared to other large EU countries, slowing down eco-innovation in the energy sector and generous incentives have sometimes benefited investors more than contributing to the overall optimization of resources.[59] In Slovenia, renewable energies have also been promoted for a long time with well-established feed-in tariffs schemes but a clearer account of the environmental impact of new energy plans still remains to be made. Italy relies largely on energy imports (77% of consumption, compared to the 49% of Slovenia)[60], which makes indigenous sources, including and in particular renewables, strategic from an energy security perspective.

54. **Agricultural governance**. In Italy, the agricultural sector is largely governed at regional level. Agricultural associations, land reclamation consortia (Consorzi di Bonifica) and wine consortia (Consorzi del vino) are powerful actors.

55. **Cross-sectoral governance, coordination and integration.** Coordination of sectoral strategies and plans presents some challenges in both countries, often because of weak institutional capacity or unclear definition of roles. Despite efforts to integrate environmental protection into sectoral development programs and river basin management plans,[61] challenges remain. In Slovenia, this is mainly due to the above mentioned lack of inter-sectoral and inter-agency coordination. With the Development Strategy of 2013-2020, the Government of Slovenia aims at improving integration of environmental and social aspects into economic development.[62] Similarly, the development of sectoral policies in Italy lead to sometimes inconsistent sectoral objectives, calling for a better coordination and mainstreaming of environmental objectives in economic development programs. Steps are

[56] OECD, 2013.Environmental Performance Reviews. Italy.
[57] OECD, 2012. Environmental Performance Reviews. Slovenia.
[58] OECD, 2013.Environmental Performance Reviews. Italy.
[59] AIGET, 2012. Evoluzione del mercato energetico italiano: alla ricerca di un filo conduttore.
[60] World Bank database, 2013.
[61] Report from the Commission to the European Parliament and the Council - On the Implementation of the Water Framework Directive (2000/60/EC). River Basin Management Plan of Solvenia, 2012. Accessible at ec.europa.eu/environment/water/participation/map_mc/countries/slovenia_en.htm
[62] OECD, 2012. Environmental Performance Reviews. Slovenia.

being taken to improve consistency. As an example, urban planning is now subordinated to environmental assessments (for instance, in areas at risk of floods - as identified in the flood management plan - urban plans need to be conformed, taking into account potential restrictions on new buildings).

Table 2
Overview of institutions relevant to managing the components of the nexus in the Isonzo/Soča River Basin

	Italy	*Slovenia*
National Authorities	IMELS – Italian Ministry for the Environment, Land and Sea Ministry of Agriculture, Food and Forestry (MIPAAF) Ministry of Infrastructure and Transport Ministry of Economic Development (MISE)	Slovenian Ministry of the Environment and Spatial Planning Ministry of Infrastructure
Governmental agencies	Institute for Environmental Protection and Research (ISPRA)	Institute for Water ARSO Slovenian Environment Agency National Civil Defence
Regional and local Level	Autonomous Region Friuli Venezia Giulia (FVG) River basin district of the Eastern Alps (ADBVE) ARPA Regional Environmental Protection Agency Regional Civil Defence Province of Gorizia, Province of Udine Managing bodies of integrated water services (water distribution, waste-water collection, etc.) Management Body of the Foce dell'Isonzo Natural Reserve (Riserva Naturale Regionale Foce dell'Isonzo) Tour operators Environmental organizations (e.g. Legambiente, WWF, Italia Nostra, Ambiente 2000)	Prefecture and local municipalities Local government water supply and sewage public companies
Agriculture	Land Reclamation Consortium of the Isonzo Plain (Consorzio di Bonifica della Pianura Isontina) Agricultural associations and wine consortia	
Energy Production	Hydroelectric companies: Connected to the grid: Edison s.p.a.; Elettra GLT s.p.a; A2A s.p.a.; Edipower; Elettrogorizia. Independent from the grid: Texgiulia spa […] (small hydropower is operated by Consorzio di Bonifica or single farmers)	Hydroelectric company: Soške elektrarne Nova Gorica - SENG d.o.o. ELES Ltd. Electricity Transmission System Operator
Basin level	[The Isonzo is one of the rivers under the management of the ADBVE]	North Adriatic River Basin District

	Italy	*Slovenia*
Regional and sub-regional organizations	European Union Alpine Convention Italian-Slovenian Commission on transboundary water management	
Transnational bodies	EGTC GO. European Grouping of Territorial Cooperation among Gorizia (ITA), Mestna občina Nova Gorica (SLO) e Občina Šempeter-Vrtojba (SLO).	

III. Identifying drivers of pressures on basin resources

56. **Water pollution.** Agricultural discharges affect water quality of surface and groundwater. In addition, pollution from urban areas, industrial sites and old mining activities (mercury) also affect water quality. Apart from the latter, which concentration is higher at the mouth of the river, the others are mostly affecting the basin of Vipava/Vipacco and the area around Gorizia.[63] Municipal wastewater treatment serves all large settlements in the basin, in both Countries. In Slovenia, the recently built municipal waste water treatment plant in Nova Gorica serves a total of 55,000 people, mitigating a known problem of water quality in the Corno River that flows into the Soča. This is part of a wastewater collection and treatment project planned in the Vipava/Vipacco river basin that will be co-financed by the EU funds.[64]

57. **Disposal sites**. There are 36 waste disposal sites in the Italian side of the basin. Five of them, located in Cividalese High Plain, cause contamination in groundwater. The Isonzo River in the municipal area of Gorizia is not free from the phenomena of dumping waste located along the river banks that are going to be solved.[65]

58. **Groundwater pressures**. In the plain in Italian territory there are major withdrawals from groundwater for domestic and drinking uses. Overall, in the FVG region groundwater withdrawals have been causing a progressive decline in the water table, with wells needing to be sunk deeper and withdrawals becoming more consistent. Water infiltration from surface water to groundwater bodies have been affecting deeper parts of the groundwater systems and recharge between aquifers sometimes compensates local groundwater depletion. This is the case in the Low Isonzo Plain, partially alimenting the Low Tagliamento Plain.[66] Naturally, the Isonzo River substantially recharges also transboundary groundwater bodies upstream (Mt. Kanin, Mt Mia and Reka-Timavo).[67] Although in the Isonzo Plain withdrawals are substantially lower than the recharge, this non quantifiable transfer should be taken into account in an estimation of groundwater resources in the

[63] Distretto Idrografico delle Alpi Orientali. Piano di Gestione dei Bacini Idrografici delle Alpi Orientali. Bacino del Fiume Isonzo. Capitolo 2: Sintesi delle pressioni e degli impatti significativi esercitati dalle attività umane sullo stato delle acque superficiali e sotterranee. Available at www.alpiorientali.it/documenti/list_doc/pub/PdP_doc_old/3-documenti_revisionati_al_18_9_2009/PIANO_GESTIONE_COMPLETO_PDF/pg_isonzo/PG_Isonzo_2_pressioni_rev01.pdf).

[64] More information on these funds can be found in the following webpage: www.eu-skladi.si/information-and-publicity/news-on-cohesion-policy-implementation/latest-news/eu-funds-for-wastewater-discharge-and-treatment-in-the-vipava-river-basin#c1=News%20Item&c1=novica

[65] Factual questionnaire compiled by Italy. 2015

[66] Zini L., Calligaris C., Treu F., Iervolino D., Lippi F., 2011 – Groundwater resources of Friuli Venezia Giulia Region: sustainability of the current use. Edizioni EUT, 89 pp., Trieste, 9-788883-033148.

[67] Franco Cucchi and Luca Zini. University of Trieste, department of Mathematics and Geoscience. ASTIS Project. *Transboundary groundwater resources*. Presentation at the Water-Food-Energy-Ecosystem Nexus In the Isonzo/ Soča River Basin. Gorizia, 26-27 May 2015.

basin.[68] Accidental discharges into surface waters can pollute these groundwater bodies because of their high vulnerability.[69]

59. **Hydropeaking**. The effects of daily flow pulsation caused by the production of hydroelectricity (hydropeaking) in the Solkan dam are reported to be apparent in the Italian part of the Isonzo River. These are rapid changes that affect both the environmental state of the watercourse and the actual capacity of derivation (at certain hours) downstream of the Solkan dam.[70] In recent years, during periods of droughts these fluctuations have made it difficult to provide water to irrigation schemes in Agro Cormonese and even more in Agro Monfalconese.[71]

60. **Floods**. High flows in the Isonzo River and its main tributaries (Torre, Natisone) mainly consist of flash floods. The 100 year recurrence interval (RI) flood (Q_{100}) of the Isonzo River occurred in 1940. The bankfull discharge ($Q_{1.5}$), the 5-year RI flood (Q_5) and the 20-year RI flood (Q_{20}) are 1,050 m^3/s, 1,663 m^3/s and 2,035 m^3/s, respectively.[72] Between 1970 and 1998 extreme flood events have become less frequent but more intense in magnitude.[73] Fortunately, settlements are mostly located in safe positions, where riverbed is wide and riverbanks high.

61. **Diversions and withdrawals**. The Isonzo downstream from the Solkan dam is largely diverted in artificial channels for agricultural hydroelectric and other uses (including industrial and fish farming).[74] Because of these diversions and the strong daily flow variations of the river flow, in times of droughts minimum environmental flows are hardly respected.[75] Responding to these needs, there have been several propositions to build a new

[68] Regione Autonoma FVG and Università degli Studi di Trieste, Dipartimento di Geoscienze. Risorse Idriche Sotterranee nel Friuli Venezia Giulia: sostenibilità dell'attuale utilizzo. 2011.

[69] Factual questionnaire compiled by Italy. 2015.

[70] Factual questionnaire compiled by Italy. 2015

[71] Distretto Idrografico delle Alpi Orientali. Piano di Gestione dei Bacini Idrografici delle Alpi Orientali. Bacino del Fiume Isonzo. Capitolo 2: Sintesi delle pressioni e degli impatti significativi esercitati dalle attività umane sullo stato delle acque superficiali e sotterranee. Available at www.alpiorientali.it/documenti/list_doc/pub/PdP_doc_old/3-documenti_revisionati_al_18_9_2009/PIANO_GESTIONE_COMPLETO_PDF/pg_isonzo/PG_Isonzo_2_pressioni_rev01.pdf).

[72] Isabelle Siché and Gilles Arnaud‑Fassetta, Anthropogenic activities since the end of the Little Ice Age: a critical factor driving fluvial changes on the Isonzo River (Italy, Slovenia). Méditerranée [Online], 122 | 2014, Online since 19 June 2016, connection on 09 September 2015. URL : mediterranee.revues.org/7253.

[73] Isabelle Siché and Gilles Arnaud‑Fassetta, Anthropogenic activities since the end of the Little Ice Age: a critical factor driving fluvial changes on the Isonzo River (Italy, Slovenia). Méditerranée [Online], 122 | 2014, Online since 19 June 2016, connection on 09 September 2015. URL : mediterranee.revues.org/7253

[74] Distretto Idrografico delle Alpi Orientali. Piano di Gestione dei Bacini Idrografici delle Alpi Orientali. Bacino del Fiume Isonzo. Capitolo 2: Sintesi delle pressioni e degli impatti significativi esercitati dalle attività umane sullo stato delle acque superficiali e sotterranee. Available at www.alpiorientali.it/documenti/list_doc/pub/PdP_doc_old/3-documenti_revisionati_al_18_9_2009/PIANO_GESTIONE_COMPLETO_PDF/pg_isonzo/PG_Isonzo_2_pressioni_rev01.pdf)

[75] Distretto Idrografico delle Alpi Orientali. Piano di Gestione dei Bacini Idrografici delle Alpi Orientali. Bacino del Fiume Isonzo. Capitolo 2: Sintesi delle pressioni e degli impatti significativi esercitati dalle attività umane sullo stato delle acque superficiali e sotterranee. Available at www.alpiorientali.it/documenti/list_doc/pub/PdP_doc_old/3-documenti_revisionati_al_18_9_2009/PIANO_GESTIONE_COMPLETO_PDF/pg_isonzo/PG_Isonzo_2_pressioni_rev01.pdf).

dam downstream to the Sokan but this was strongly opposed by citizen groups and environmental organizations.[76]

62. **Natural porosity of riverbed**. In the Italian upper basin (upstream of Gorizia) the riverbed is highly porous (while it is not around Gorizia and in the plain). In drought times and with daily fluctuations of flow, the river appears completely dry. In these cases the river is recharged by groundwater downstream of the city (at Pieris).[77]

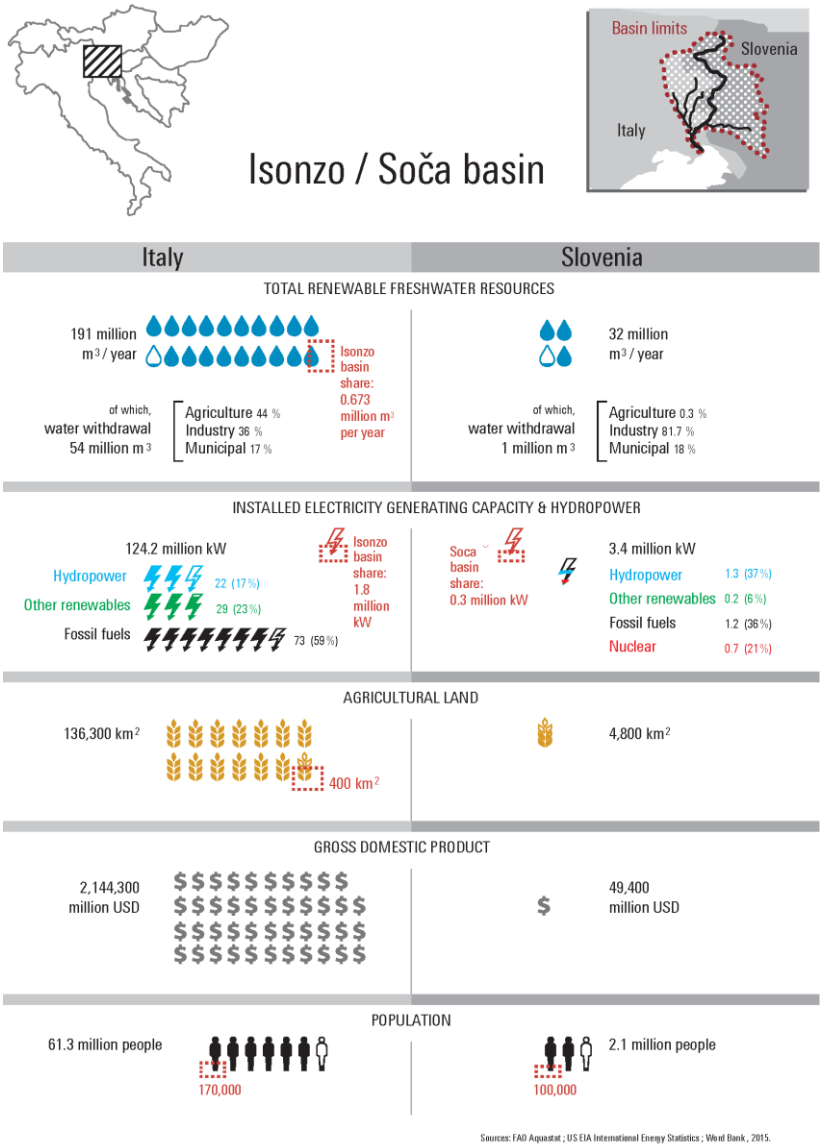
63. **Land use and hydro-morphologic changes**. Land use changes that characterized the last century in the basin have been described earlier (see 1.3). These caused significant changes in the fluvial system, namely a decline in sediment transport and narrowing of the river's active channel in some tracts. Sediment load has reduced following hydraulic works: coarse sediments are mostly retained in dams, while suspended load has reduced following slope restoration.[78]

[76] Isonzo laboratory - Participatory process to identify joint proposals on cross-border management of the Soca River in relation to the commitments undertaken by Italy in the Osimo Agreements (Friuli Venezia Giulia region and Alto Adriatico River Basin Authority).

[77] Distretto Idrografico delle Alpi Orientali. Piano di Gestione dei Bacini Idrografici delle Alpi Orientali. Bacino del Fiume Isonzo. Capitolo 2: Sintesi delle pressioni e degli impatti significativi esercitati dalle attività umane sullo stato delle acque superficiali e sotterranee. Available at www.alpiorientali.it/documenti/list_doc/pub/PdP_doc_old/3-documenti_revisionati_al_18_9_2009/PIANO_GESTIONE_COMPLETO_PDF/pg_isonzo/PG_Isonzo_2_pressioni_rev01.pdf).

[78] Isabelle Siché and Gilles Arnaud-Fassetta, Anthropogenic activities since the end of the Little Ice Age: a critical factor driving fluvial changes on the Isonzo River (Italy, Slovenia). Méditerranée [Online], 122 | 2014, Online since 19 June 2016, connection on 09 September 2015. URL : mediterranee.revues.org/7253.

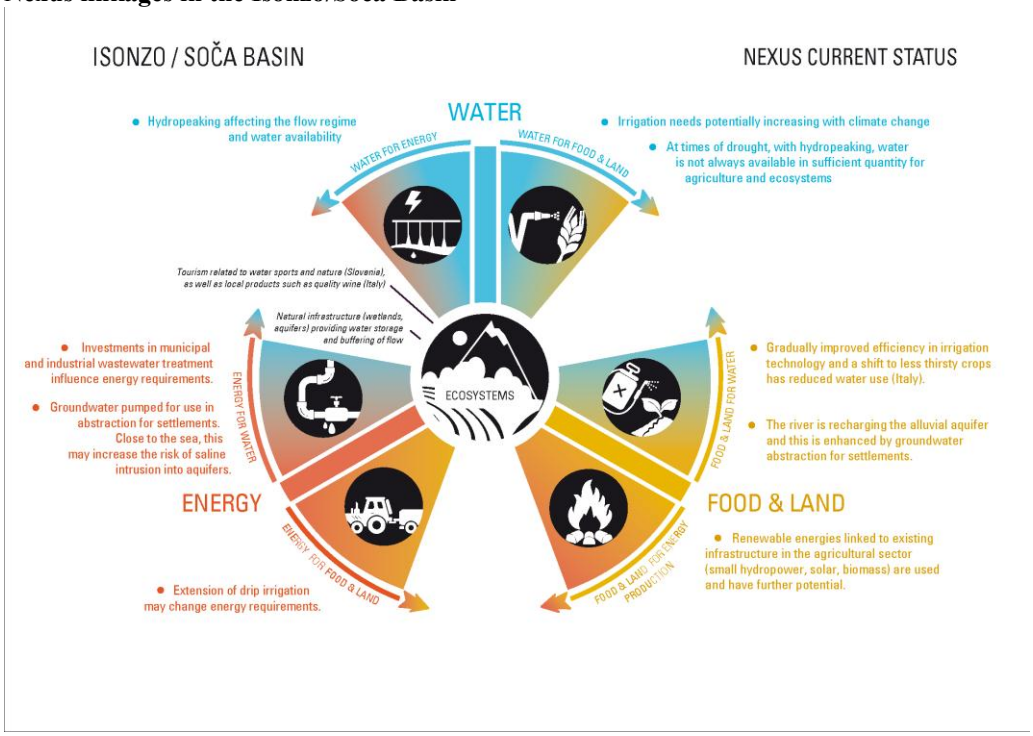
Figure 4
Key indicators describing the resources and socio-economics of the Isonzo/Soča River



IV. Analyzing nexus linkages

64. Figure 5 shows an overview of the main intersectoral linkages identified. The interlinkages are discussed in more detail below, although it should be said that a much more in-depth level of detail would be required in a more comprehensive nexus assessment. It should also be noted that the next chapters take into account practically only the part of the basin located in the territory of Italy.

Figure 5
Nexus linkages in the Isonzo/Soča Basin



A. Ecosystem services, natural capital and tourism

65. The basin has an important natural capital. This needs to be protected and preserved to ensure a good functioning of a variety of ecosystem services from water purification and provision for various uses, to energy and food production, tourism and biodiversity. Green infrastructure[79] helps first of all to sustain the water cycle (e.g. groundwater recharge), which directly benefits local population with water storage and flood protection. Multiple and intersectoral benefits could, however, originate from this green infrastructure: taking into account, for instance, the widespread woods in the basin, improving the sustainable management of these forests can enhance the slope stability reducing the effects of natural hazards, increasing evapotranspiration and retention of water, providing raw material for the lumber industry (as well as energy and heating production) and enhancing tourism in the territory and raising carbon storage.

66. Because of its high potential and low environmental impact, a 'slow tourism' focusing on nature, sports, historical heritage and local products is promoted in both Countries. The tourism potential in the basin focuses on:

(a) River and mountain related sport activities - Soča Valley (Slovenia);

(b) Biodiversity - Isonzo mouth, lagoon;

(c) WW1 paths and memorials – Italian-Slovenian border;

(d) Vineyards and local products - Collio hills.

[79] Natural infrastructure, such as forests, floodplains and riparian areas, can provide many of the same services as built infrastructure, including the ability to filter water, minimize sedimentation.

67. Ecosystem services can be partially valued in economic terms, which illustrates the direct impact that their degradation would have on the economy or the benefits that a use of green infrastructure would disclose. This type of analysis, which is starting to be applied in the region[80,81], helps connecting the environment with the 'productive sectors' that drive development.

B. Water-energy-ecosystems: river-flow continuity

68. River-flow continuity is a necessary condition to maintain ecosystems in a river. There is no universal or widely accepted methodology to establish the environmental flow of a river.[82] This is partly because of complexity of the matter: many parameters that need to be established and the related data requirements. Also in the Isonzo River, an evaluation of the environmental flow is not straightforward. According to the methodology developed at the FVG region, due to the different hydro-morphological conditions, minimum flow values are different in upper and lower basin of the Isonzo River.

69. The absence of counter-regulation infrastructure in the Italian side results in hydropeaking directly causing daily cycles of water stress and high flow in the river course. As mentioned earlier, in low flow conditions some tracts of the river can dry up temporarily.[83] This affects not only biodiversity (including the endangered marble trout) but also other uses downstream, in particular the agricultural sector and irrigation. In addition, where anthropic pressure is high, water scarcity means less dilution of discharges or stagnation, with potentially negative impacts on water quality and, consequently, health.

Box 1 includes the illustration of a few possible management options to address hydropeaking in the Italian side. It should be noted that these results come from an independent research effort of the Royal Institute of Technology[84], which nevertheless contributes to the thematic of this nexus assessment. Notably, it offers interesting insights on the energy-water interlinkages in the basin and could provide a starting point for the analysing possible scenarios to enhance river flow continuity.

Box 1
Improving flows downstream of the pumped storage plants.

The hydro-peaking phenomenon results when water is accumulated during low electricity price hours. It is then released when prices are increased during the peak periods of the day. Such fluctuation leads to daily flow variations, potentially affecting the hydrological and biological state of the watercourse and water-dependent ecosystems downstream from the dam. In the Isonzo/Soča Basin, the river represents the principal source of water for irrigation on the Italian side.

[80] See for example the impact of forest loss in the Alpine region: Tiina Häyhä, Pier Paolo Franzese, Alessandro Paletto, Brian D. Fath. *Assessing, valuing, and mapping ecosystem services in Alpine forest*. Ecosystem, Services 14 (2015) 12-23.

[81] See for example the potential economic benefit associated to monitored aquifer recharge (MAR) in Veneto and FVG regions: TRUST project, 2011. Documentation available at: www.lifetrust.it/cms/it/eventiadownloads/divulgazione/110-layman-report.html

[82] The European Commission has been reviewing the related practices of the member States and is expected to come up with some guidance.

[83] Agenzia Regionale per la Protezione dell'Ambiente del Friuli Venezia Giulia (ARPA FVG). Presentation at the Water-Food-Energy-Ecosystem Nexus In the Isonzo/ Soča River Basin. Gorizia, 26-27 May 2015.

[84] This work too benefited from the input of Italian experts involved in the nexus assessment process.

When a low amount is discharged, uptake of water for agricultural use in the irrigation infrastructures may be affected. At times of drought in particular, with hydro-peaking which on the Isonzo/Soča is mainly observed close to the boundary between Italy and Slovenia, water is not always available in sufficient quantity for agriculture and ecosystems. Ecosystems are affected resulting in negative impacts on activities that might rely on those. For example marble trout fishing and other recreational pursuits from which tourism may benefit are lost.

Reservoir storage capacity and flow regulation that it provides for allow for optimization of water use for different objectives (or co-optimization). The example below illustrates the related considerations and trade-offs.

Research carried out at the Royal Institute of Technology (KTH, Stockholm),[a] based on a specifically constructed an energy-water model to analyse the costs associated with different approaches to reducing the effects of hydropeaking. In the first approach, different dispatch rules are applied to turbines of the Solkan hydropower plant (with the associated reservoir representing the largest reservoir storage on the Isonzo/Soča), in order to increase the minimum water flow released. In the second approach, the building of a new storage facility in Italian territory aimed at balancing the oscillating discharge is simulated.

The first approach consists of ensuring there is a minimum discharge of 25 m^3/s. This increment aims to improve the water availability for agricultural purposes on the Italian side this but would also help reducing environmental stress on the segment of the river upstream the dam, which is affected by hydro-peaking. Changing the dispatch of the Solkan turbines would cause an income reduction for the hydropower company (Soške elektrarne Nova Gorica - SENG d.o.o.) because the production will not be maximized in the peak cost hours anymore. The efficacy and cost of this change depend on the year typology (average or dry) as well as on the criteria of the new dispatch rules. The highest annual income reduction - "Worst case income reduction"- corresponds to a dry year. This would be equal to some 533,000 € per (dry) year. While the lowest annual reduction is observed in an average year - in the sub-case "Minimization of the number of hours with a discharged flow lower than the minimum required" - and applying the methodology only in the summer months, the most critical for the agricultural sector, this would correspond to an expenditure/loss of profit of approximately 10,900 €. In average, considering each year and each sub-case, the annual revenue reduction is equal to 158,000 €.

In the second approach, the necessary storage size is calculated to satisfy the minimum flow requirement for each single hour of each year. With this method, the obtained values of storage needed are high. An ideal storage size is therefore evaluated. This would only guarantee the minimum flow in the majority of hours of the year. The outcome suggests an optimal size of 1,000,000 m^3, ensuring the minimum flow requirement for 8,000 hours in the dry years, and for 8,600 hours in the average years. In this case, the costs associated depend on the type of storage capacity. Opportunities exist to store water in different locations (small basins, floodplains, groundwater bodies), potentially drastically reducing costs. The feasibility of these options was not part of this study.

Due to uncertainties concerning the dispatch rules of the Solkan hydropower plant and to the fact that in the second case there are different types of investment to be evaluated, it is difficult to compare these two solutions from an economic (cost) point of view. Moreover, these costs are completely different in nature: the first one is an annual lost profit whereas the latter is an investment cost.

Furthermore, neither the first nor the second would ensure a water flow equal at

least to the specified minimum. In fact, the capacity of the Solkan dam and the ideal Italian storage size are analogous.

While being only rough and indicative, the above example illustrates the kinds of costs are involved adjustment of an operation regime. As the significant range of costs associated with the first approach, from 10,900 € to 533,000 €, demonstrates, the result depends on the availability of data and its quality. Done with more comprehensive data, a more accurate estimate could be obtained.

However, there is exists a significant opportunity in the form of refurbishing infrastructure that is on the point of collapse. In particular at a site called TexGiulia, not far from the boarder, lies an old barrage in dis-repair. If left unattended it will become a hazard, with dangerous water flows and debris released as it collapses. Thus there is no option, but to refurbish or decommission it. However, if refurbished, a total volume of the required 1,000,000m^3 might technically be harnessed. Given that inaction will cause damage, but judicious action might avoid environmental impacts as well as alleviate the hydro-peaking problem, further investigation is suggested.

[a] Chiara Mei, Politecnico di Torino and KTH Royal Institute of Technology. *The Water, Energy and Land linkages on the Isonzo-Soča river basin*. 2015.

C. Water-food-energy in the agricultural sector

70. Channel irrigation is an almost completely abandoned technique in the Isonzo plain (Italian side). Sprinkler irrigation is very widely used and the share of drip irrigation is increasing.[85] Corn cultivations are being abandoned for less water requiring and more valuable crops, grape in particular. In response to more frequent droughts episodes, the land reclamation consortium[86] is planning to ensure irrigation infrastructure to all fields, including vineyards. Even if these would not need irrigation in a normal year, but it is important to guarantee the opportunity to use it in case of drought. The consortium keeps on investing in efficient irrigation, which has so far resulted in a 50% reduction of water use in irrigation since 1990.[87] The shift from sprinkler irrigation to drip irrigation indirectly results in energy savings.

71. Electricity in the agricultural sector is supplied by the national grids but small decentralized productions also exist. The integration of renewable energy sources into existing agricultural buildings and infrastructure consists mainly of small hydropower, which is widely used in combination with diversion channels of irrigation schemes. Integrating solar is also possible – e.g. on roofs of agricultural buildings – but currently there are no programs (e.g. feed-in tariffs) that would incentivize a wide implementation of this technology.

[85] Significant investments are made to implement drip irrigation for at least for tree cultivations, such grapevines, olive trees and fruit trees (source: Factual questionnaire compiled by Italy, 2015).

[86] In Italian 'Consorzio di Bonifica' – a public body that manages infrastructural projects for agriculture, including irrigation works.

[87] Factual questionnaire compiled by Italy, 2015.

D. Energy-water

72. Energy is increasingly used in the water sector. Firstly, groundwater withdrawals require energy for pumping and wells are mostly used for drinking purposes. Secondly, the process of wastewater treatment also requires energy. Water on the other hand is needed to produce electricity: water is used for hydropower production but it is also withdrawn by thermal plants for water cooling and demineralised water production, although their overall abstraction is not very high.[88]

E. Water quality

73. As mentioned earlier, agricultural discharges constitutes one of the main pressures on water quality, affecting surface and groundwater in proximity of agricultural areas. Punctual pressures are limited and with the exclusion of mercury (which long-term impact still needs to be examined) not significant. The ecological status is being assessed in all tracts of the river.

74. Groundwater contamination can be caused by infiltration from surface water, by saltwater intrusion in the coastal zone or by contact between different aquifers. As this could lead to contamination of drinking water, this needs careful assessment and monitoring.[89]

F. Future trends

75. In the future, these linkages will develop following socio-economic and climatic changes. Although estimates for the basin do not exist, the Alpine region overall is not expected to experience population increase. Potentially this could even decrease due to migration from rural and mountainous areas.[90]

76. Overall, the Mediterranean region will experience a temperature rise (between 2.5 and 7°C) and a moderate decrease in precipitation (around -10-15%) by the end of the century. On the basis of this input, the hydrogeological model developed for the TRUST project (including the area of the Isonzo, Tagliamento, Livenza, Piave and Brenta rivers flowing eastwards, and the far western Bacchiglione river) shows that river flows will increase in winter and decrease in summer, spring and autumn.[91] This will likely impact groundwater recharge (by the end of 21st century, the annual aquifer recharge in FVG Veneto could lower by 11%, corresponding to a reduction of available groundwater of 335 million m³) and crop production (water available for irrigation would decrease by 10 - 15%).

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[88] Chiara Mei, Politectnico di Torino and KTH Royal Institute of Technology. *The Water, Energy and Land linkages on the Isonzo-Soča river basin*. 2015.

[89] This is being undertaken by the Distretto Idrografico delle Alpi Orientali and at transboundary level, within the ASTIS project.

[90] Permanent Secretariat of the Alpine Convention. *Sustainable Rural Development and Innovation*. Report on the State of the Alps. 2011. Available at www.alpconv.org/en/AlpineKnowledge/RSA/sustainable/Documents/20110906RSA3_longversion_en.pdf.

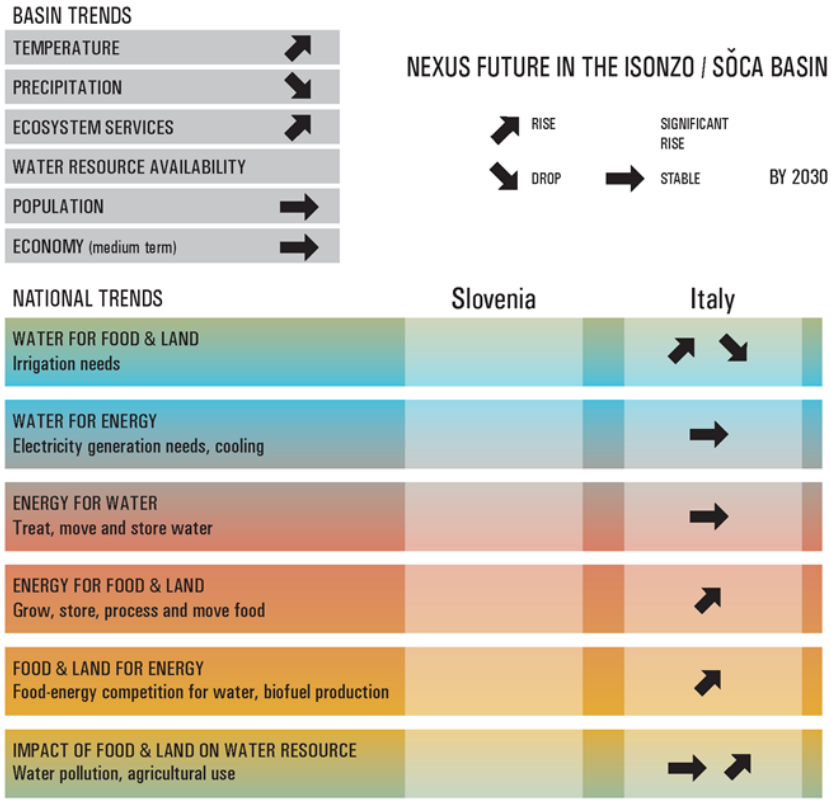
[91] TRUST project, 2011. Documentation available at: www.lifetrust.it/cms/it/eventiadownloads/divulgazione/110-layman-report.html

77. A shift to a more extreme climate (with hotter and longer summers) has been observed already in the basin.[92] Climatic trend predictions and flow reductions described above suggest that this trend may continue. It should be noted that while water needs may increase due to climate change, shift to less thirsty crops and the use of more water efficient technologies may balance it, reducing overall consumption. Nevertheless, if droughts will become more frequent, irrigation infrastructure may become necessary to avoid yield losses.

78. The evolution of interlinkages is reported in Figures 6 (only for the Italian side of the basin). Trends have been evaluated on the basis of available information. They show an increase in water and energy efficiency in agriculture, but at the same time a decrease in water availability for ecosystems – due to the combined effect of climate change and hydropeaking.

79. Water use efficiency is expected to compensate the increase in water needs in irrigated areas. Shifting from sprinkler to drip irrigation, energy efficiency will also increase.

Figure 6
Future trends among nexus linkages in the lower Isonzo/Soča River Basin



80. Investments in the agricultural sector will determine water and energy demands of the sector. Renewable installations will still depend on incentives: because energy is neither scarce nor unaffordable to farmers, investments in small hydropower and solar will probably happen only if they will have a clear financial return.

[92] Information from working group discussion at the workshop.

81. The evolution of cooperation can significantly affect economic development in the basin. A range of new developments could arise from improved cooperation, from coordinated river continuity restoration and environmental protection, to tourism at basin scale, to various types of trade, energy exchange etc.

V. Exploring solutions towards building a green economy in the basin

82. Adopting a nexus approach to the assessment of the river's natural resources helps linking sectoral considerations and putting them in the broader context of sustainable development. In practice, it highlights the opportunity to value natural capital that would result from a more coordinated management of the basin and a better understanding of cross-sectoral implications and opportunities.

83. From the workshop, two main 'solutions' were identified collectively:

(a) Exploring potential for basin-level green economic growth - taking advantage of complementarities between the two sides of the basin (e.g. natural and cultural tourism);

(b) Restoring river continuity - increasing drought resilience, while at the same time reducing stress on riverine ecosystems.

A. Institutions

84. *Review the scope of transboundary cooperation of the Italian-Slovenian Commission for the hydro-economy*. This currently focuses mainly on technical issues of hydrology. Widening its scope could help discussing benefits of cooperation at a broader level, taking into account the common natural and historical capital on which both countries (and regions) currently invest on to pursue green growth objectives.

B. Information

85. Improve cooperation across the border and exchange of good practice, preparing for climate change impacts and needed adaptation: For example, in the agricultural sector (e.g. efficient technologies, integration of renewables) and in the touristic sector (sustainable, slow tourism). Given the expected impact of climate change on the basin, exchanging good practices for adaptation (e.g. most appropriate crops) would be particularly appropriate.

86. *Better monitor groundwater uses*. This appears to become a common challenge, requiring joint assessment and monitoring as well as response to hazards. A response action could be the establishment of a transboundary action system for the Civil Protection agencies in the two countries to cooperate in case of groundwater contamination due to both technological risks and natural disasters.[93]

87. Communication efforts aimed at raising awareness about the importance of the river basin thanks to its characteristics and its natural capital, its contribution to improving the quality of life and the attractiveness of tourism would be valuable. This could also contribute to the socio-economic development of the basin and to preserving its qualities. A prerequisite for this to happen is that an effective communication and exchange between policy makers and managing authorities of the basin, both Italian and Slovenian, is in place.

[93] Alberto Cisotto. *Groundwater Resources*. Presentation at the Water-Food-Energy-Ecosystem Nexus In the Isonzo/ Soča River Basin. Gorizia, 26-27 May 2015.

They would benefit from assessing together and implementing useful initiatives to promote the natural capital and prevent any deterioration in the conditions for the implementation of EU Directives, i.e. the Water Framework Directive 2000/60 and the Floods Directive 2007/60.

C. Instruments

88. Systematic use of the following regulatory instruments would be beneficial in the basin:

(a) Environmental Impact Assessments (for projects);

(b) Strategic Environmental Assessment (for policies and programmes);

(c) Minimum environmental flows - regulated by law and to be agreed at transboundary level.

89. *Economic instruments could help increasing the share of renewables but they should be carefully managed.* For instance, incentives for small hydro-electricity production become a remunerative business that may cause unnecessary diversions and alteration of the river morphology. In order to avoid further disruption of the river's continuity, small hydropower should only be built where the diversion already exists. Overall, small hydropower development should follow clear guidelines.[94]

D. Infrastructure

90. Restore existing infrastructure and assess the potential of storage capacity alternatives prioritizing the use of green infrastructure. The dam of TexGiulia in particular, already requiring restoration to address the present hydro-geological risk associated to the dam, could significantly contribute to provide a buffer to hydropeaking (see Box at page 23). However, it should be taken into account that any intervention generating a steady elevation of the Straccis basin can potentially endanger the natural and touristic enhancement of the river course of the Isonzo straddling the border between Gorizia and Solkan resulting in the drowning of paths and beaches. This means that even an intervention aimed at enhancing the capacity of existing infrastructure should be carefully planned to address such adverse impacts according to the principles of environmental impact assessments. The potential of natural infrastructure should be also explored. The opportunity to implement managed aquifer recharge (MAR) has been already evaluated in the framework of the TRUST project and, which concluded that MAR techniques could restore groundwater by 70% of the groundwater deficit induced by climate changes in the FVG region.[95]

91. *Continue promoting multi-sectoral use of infrastructure and advanced practices in agriculture, including new technologies (for water efficiency, energy efficiency and on-site energy production from renewables).* In particular, photovoltaic roof system is considered a good solution because of its high potential and social acceptance.[96]

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[94] See for example: Alpine Convention, Platform water management in the Alps. *Common guidelines for the use of small hydropower in the Alpine region*. 2011. Available at www.alpconv.org/en/publications/alpine/Documents/SHP_common_guidelines_en.pdf

[95] TRUST project, 2011. Documentation available at: www.lifetrust.it/cms/it/eventiadownloads/divulgazione/110-layman-report.html

[96] Permanent Secretariat of the Alpine Convention. *Sustainable Rural Development and Innovation*. 2011. Available at

92. *Ecological river restoration. Promotion of solutions and approaches on a number of river restoration themes* that promote urban resilience, sustainable land use and hydropower, hydro-morphological continuity and fish migration, and result in balancing ecological and economic benefits.

E. International cooperation and coordination

93. *Potential for basin-level green economic growth taking advantage of complementarities between the two sides of the basin*. A common vision of sustainable tourism exists in the Alpine region.[97] As landscapes change significantly along the river and the historical heritage is largely common between the countries, it would be interesting to explore options for development of tourism in the basin as a whole (e.g. touristic packages or paths across the border and along the river).

94. *More coordinated management of the river*. The river basin management plans could be more explicitly coordinated if not jointly developed in the future. This could be based on integrated analysis of the basin and exchange of information, which would allow to optimize resource use, to find optimal location for development of infrastructure, to develop common projects[98] and so on.

VI. Conclusions, recommendations and next steps

95. Both riparian countries as Parties to the UNECE Water Convention are obliged to use their shared waters in an equitable and reasonable way, not to cause significant harm and to cooperate in the management of these waters.

96. The nexus assessment of the Isonzo/Soča has been initiated with this scoping-level exercise involving a desk study and a workshop involving Italian authorities and other key actors, complemented by consultation of experts. This document presents some initial findings that can inform more specific scoping and selecting most appropriate focus for applying a nexus approach to the Italian-Slovenian joint assessment of the basin's resources. This provided that follow up is agreeable to both countries, an agreement can be reached between the riparian countries on the scope and the necessary resources mobilized. Furthering the transboundary dialogue would help the countries move towards a more holistic approach to managing the basins resources, a greater coherence between policies, more efficient resource use and greener economies.

97. Key findings from this scoping level assessment include:

(a) Existing high potential to promote green growth in both countries, most importantly sustainable natural and cultural tourism as well as development and optimization of renewable energy sources;

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www.alpconv.org/en/AlpineKnowledge/RSA/sustainable/Documents/20110906RSA3_longversion_en.pdf

[97] Permanent Secretariat of the Alpine Convention. *Sustainable Tourism in the Alps*. Report on the State of the Alps. 2013. Available at www.alpconv.org/en/AlpineKnowledge/RSA/tourism/Documents/RSA4%20en%20WEB.pdf

[98] The analysis of the upstream Soča in Slovenia in the framework of the CAMIS project allowed to conclude where the most advantageous places for bathing sites, hydropower, fish farming and fishing sites are. See dr. Aleš Bizjak, mag. Sašo Šantl, Andrej Bašelj, Matej Cunder, Klemen Šavli, Andrea Skroza, Lucija Marovt, *Integral assessment of suitability of the main watercourses in the Upper Soča Basin for selected present water uses*. CAMIS project.

(b) Existing complementarity between the countries in terms of landscape and activities;

(c) Potential to exchange good practices across the border;

(d) Necessity to improve river continuity to support river ecosystems;

(e) An increasing interdependency between sectors due to climate change and consequently related trade-offs perhaps surfacing more prominently in the future.

98. As proposed in this document, there are two main themes that, if further developed, could serve as narratives in the nexus assessment of the Isonzo/Soča. These have been identified with Italian stakeholders in the course of the scoping level assessment. The first is 'river continuity', meaning the capacity of the river to support a number of services all along its course. From a nexus perspective, the aspect of ecosystems connectivity is as important as hydrological continuity and water quality. The second one is 'eco-tourism', highlighted to have a high potential in terms of green jobs. Specific opportunities have not yet been evaluated, but a number of them emerged during the course of consultation. The rich biodiversity (including the presence of endemic species), the presence of local eno-gastronomic products (some with controlled designation of origin) and a growing offer of sport-related tourism directly linked to the river, all suggest that such opportunities are relevant. Moreover, a flourishing eco-tourism requires other sectors to be fully functional. For instance, natural and built infrastructure should allow the river to be accessible for bathing, fishing and biking wherever appropriate (as identified for example in the CAMIS project). Eco-touristic packages would be more appealing if they reach urban areas to combine the nature related aspects with cultural events. This would require paying attention to quality of services and appropriate facilities for visitors, including last-mile transport solutions. Increasing attractiveness and accessibility of this wide natural and historical capital and integrating the different potentials into tourist packages, even transboundary ones, is a challenge and addressing it requires development efforts in different sectors, including river restoration, forest management, transports and agriculture,among others.

99. From the findings of this scoping level exercise it is clear that the nexus assessment of the Isonzo/Soča has potential to promote the transboundary region around the basin. Specifically, the nexus assessment could help exploring a number of opportunities to enhance green growth – a priority for both countries – taking into account the various negative and positive impacts of each intervention across sectors.

100. The highly participative dimension of the nexus assessment has proved to be very useful in reflecting the actual concerns and priorities of local stakeholders in the Italian side, also in accordance to the Aarhus Convention. Once completed including the perspectives and inputs from Slovenia, the nexus assessment could form a concrete proposal from the ground, jointly developed between the two countries to promote their common heritage in a view of green growth in the basin region.

101. The nexus, so far explored only at a scoping level, and mostly in terms of water, food and energy, could be widened to consider all aspects that play a role in the enhancement of a green economy. First of all, the role of cities as centers of human activities and potentially providers of green jobs could be deepened. This could entail aspects such as the valorization of green areas and historical heritage, the promotion of cultural events promoting the territory, but also technical solutions to enhance energy efficiency in buildings and waste management. Similarly, with regard to extra-urban and rural areas the assessment could focus on landscapes and natural capital. Most importantly, the fundamental role of forests could be highlighted, together with their role in the water cycle, microclimate regulation and other ecosystems services.

102. The Isonzo/Soča river is a natural bridge between the Alps and the Adriatic Sea. In this sense, its importance goes beyond the local level. A vision of the basin as a regional

example of sustainable, green development not only is interesting from the perspective of the basin's communities, but also reflects the ambition of the work that is being carried out at the levels of both the Alpine area and the macro-Adriatic region. Hence, future work on the nexus in the Isonzo/Soča could well be presented in these arenas and proposed as testing ground for such an innovative approach.