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Background document to Deliverable 5.1 - Governance, policy and financial mechanisms for TAP adoption and upscaling

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Contents

1. River basin status

1.1. Drivers, pressures, status, and outlook

1.1.1. Which is the quantitative status of water bodies in the area?

Answer this question using data from river basin plans, in the case of the EU from the 3rd cycle RBMP.

1.1.1.1. Júcar River Basin (Spain)

Description:

The Júcar River Basin (JRB) is a semi-arid area which covers 22,261 km2 with the Júcar stream (512 km long), being one of the most important rivers in Eastern Spain. It starts at the Iberica mountain range, besides the San Felipe hill, at 1,585 m height. The river flows along the Cuenca, Albacete, and Valencia provinces until it meets the Mediterranean Sea. The annual precipitation ranges between 309 and 717 mm, with an average of 473 mm. Its precipitation pattern is typically Mediterranean: high rainfall in autumn (especially in October), with a second peak in April–May, and very little precipitation during summer. The combination of high water demand and hydrological variability forces adaptation by different management strategies, as water storage infrastructures, conjunctive use of surface and ground waters, and institutional and legal development. The total average available water resources are 1,668 mm3 per year, mostly from groundwater; 75% of the average river flow is regulated through surface reservoirs, with Alarcon (1,118 mm3 of useful capacity; upper basin) and Tous (378 mm3, lower basin) the two largest along the main course of the river, together with Contreras (852 mm3) (Escriva-Bou, Pulido-Velazquez, and Pulido-Velazquez 2017). The largest amount of water use is for agricultural use (89%), followed by urban (9%) and industrial uses (2%).The Júcar River system also holds 31 hydropower plants (with a total installed capacity of 1,272 MW). There are permeable materials that al-low rainfall infiltration into the aquifers of La Mancha Oriental (middle part of the basin, Molinar) and La Plana de Valencia (lower basin, Sueca), where groundwater is abstracted (Suárez-Almiñana et al. 2020).

Outlook:

Water resources in the Júcar River Basin will be reduced by climate change according to most projections. Some areas could see a 40/50% decrease compared to the late 20th century level, depending on the source. The upper part of the basin, where most reservoirs are located, are expected to experience the largest reductions. This could affect the interannual storage needed to cope with droughts. The percentage of decrease is uncertain, but most CMIP5 projections agree on a reduction of 25/50%, so the confidence level is high. Moreover, future drought indices projections indicate more frequent and severe droughts, which will challenge the water use sustainability in the system. This decrease will have impacts on all water uses: urban supply, agriculture, hydropower, and environmental status. Agriculture and environment are expected to be the most affected. Agriculture has an 80% share of total water use and lower priority than urban supply, so it will face the biggest water delivery curtailment among consumptive uses. The environmental status of water and dependent ecosystems will also be challenged by lower streamflow and competition with agriculture. Hydropower production may also suffer a significant decrease, but it is expected to be lower than in the previous sectors. According to the Júcar River Basin Management Plan of the JRB district, 53% of their natural river reaches will not reach a good status before 2027 as required by the WFD. Likewise, all heavily modified or artificial reaches will not reach a good status. The situation is better for reservoirs, with 86% expected to show a good status by 2027, but it worsens for natural lakes (63%) and even more for heavily modified or artificial lakes (50%). The overall evaluation of surface bodies shows that 52% will not reach the good status by 2027 required by the WFD. The situation of groundwater bodies is similar, since 46% will not reach a good status before the original deadline of the WFD. This situation is combined with a heavily committed basin in terms of water resources, since consumptive water demands account for 95% of the average surface water resources.

1.1.1.2. Nitra River Basin (Slovakia)

Nitra RB is a sub-basin of the Váh River, which in turn is located within the Danube RB. According to the 3rd cycle RBMP, the area of Váh RB is 18 769 km^2, the precipitation is 788 mm and the runoff 268 mm. Thus, the evaporation is 520 mm. Average annual water flows in the Nitra RB were in the range of 59-129% of the long-term average (1961-2000). The total water withdrawal in the Nitra RB including both surface and groundwater decreased from 0.977 $m^3 s^{-1}$ to 0.947 $m^3 s^{-1}$ (3.1%) between 2019 and 2020, whereas the withdrawal of surface water decreased by 12.1% and the withdrawal of groundwater increased by 0.1%.

The highest amounts of groundwater are accumulated in Quarternary sediments in the Nitra River alluvial plain and its larger tributaries. Alluvial plain groundwater is mostly hydraulically interconnected with the surface streams. Wells´yields reach up to 15 $l.s^{-1}$ (Fendeková and Fendek, 2012), which is less than the groundwater withdrawal in the study site location 18 $l.s^{-1.}$ Thus, the groundwater abstraction levels are at the full use potential, which negatively affects the quantitative status of the groundwater reservoirs.

Nitra river originates in Strážov Mts. At an elevation of approx. 800-850 m a.s.l. and flows from north to south. The most important tributaries are Handlovka, Nitrica, Bebrava, and Žitava. All climate types (climatic-geographical) that occur in Slovakia occur also in the Nitra RB depending on the altitude: from warm to moderately-warm to cold.

1.1.1.3. Reno River Basin (Italy)

The Reno basin mainly lies in the administrative territory of the Emilia-Romagna Region, while the source is in Tuscany Region.
For many Tuscan mountain portions of the Reno sub-basins, specific agreements/conventions have been made: the main water services and the ordinary maintenance of the territory are carried out by subjects/managing bodies of the Emilia-Romagna Region.

For surface water, the quantitative status is not evaluated and defined. The natural water bodies of the basin have a strong torrential character: about 30% of them presents a naturally non-perennial hydrological regime; about 31% have an altered hydrological regime that could be due to punctual but relevant withdrawals, diversion of water resources for hydroelectric and irrigation use, or by a plurality of minor withdrawals for different uses, in particular irrigation.

The groundwater bodies belonging to the Reno basin include aquifers of the hillside and mountain portion of the regional territory (sources and deposits of the valley floor) and aquifers of the plain portion (water bodies belonging to the system of Apennine alluvial fans and the Apennine and Po alluvial plains).

Most of the regional water bodies in the basin are in Good Quantitative Status (about 97%), while only two fan aquifers are in Bad Status.

1.1.1.4. Tympaki River Basin (Greece)

The Tympaki study area encompasses a basin of about 265 km2, and comprises according to the WFD typology, of 7 river water bodies, and 6 groundwater bodies. It is part of the wider Messara plain in Greece, the main agricultural productive area of Crete island. Physiographically, the basin comprises of the Tymbaki plain to the west and the Tymbaki hills area to the east, and is crossed by the Geropotamos river (Koutsoulidis and Mageiros branches).The Tymbaki plain is by far more important for groundwater exploitation than the hills' area, due to its higher permeabilities, higher specific capacities, and and more favorable morphological conditions.

Land use in the Tympaki study area is dominated by agriculture (40% overall in the basin, and 88% in the central plain of Tympaki). The population in the Tympaki area is about 11,000 inhabitants. About 7.5 million m3 are annually abstracted from groundwater for irrigation purposes in the central plain of Tympaki (to irrigate about 40 km2).

As presented in the table below, the quantitative status of 1 of the 6 groundwater bodies is poor. More specifically, the GWB EL1300082 faces significant pressures of over-abstraction for irrigation purposes, which has led to salinization and seawater intrusion, quantitative and qualitative deterioration.

Groundwater body (GWB) code	GWB name	Surface area (km2)	Mean Annual Recharge (mio m3)	Estimated Mean Annual Abstraction (mio m3)	Main Land use	Quantitative Status
EL1300055	Porous system of Notio Rethymno	6.83	1.41	0.62	Agricultu re (70.0%)	Good
EL1300065	Karstic system of NA. Psiloreiti	113.89	70.71	0.73	Pasture (72.8%)	Good
EL1300081	Porous system of Tympaki Basin	28.69	6.53	6.37	Agricultu re (91.7%)	Good
EL1300082	Porous Coastal system of Tympaki basin	6.3	0.63	0.99	Agricultu re (72.4%)	Poor
EL1300086 (part of)	Porous system Messaras-Notiou Heraklio u	48.91	6.16	5.98	Agricultu re (75.8%)	Good
EL1300250	Fractured System of Psiloreiti	60.39	6.23	1.07	Agricultu re (47.4%)	Good

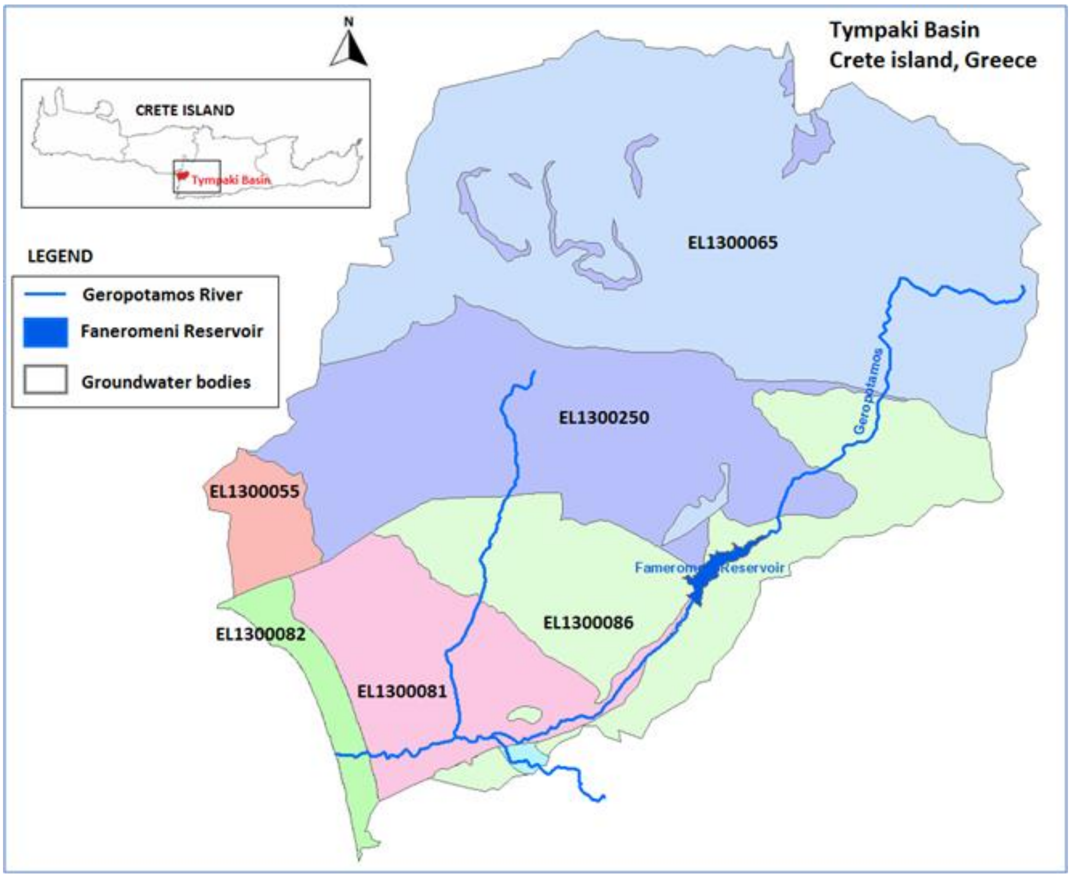


Figure: Representation of the Tympaki Basin in Greece

1.1.1.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

The basin has a water deficit to supply the different activities carried out and to guarantee the health of strategic and vulnerable ecosystems such as the wetlands (bofedales) and their relationship with camelids. This transboundary system has two basins: in Peru-Chile the Caplina Locumba Sama basin system and in Bolivia the Mauri basin corresponding to the Titicaca-Desaguadero-Poopo system and the Coipasa Salt Lake TDPS. (Comisión Técnica Binacional (CTB) de la cuenca del rio Maure –Mauri, 2019). The Mauri basin has a history of water transfers to the Pacific hydrological region in Peru and Chile since the early 1900s. These extractions have been transferred to the Tacna region by the Peruvian government, generating conflicts between the countries due to water shortages in both system (Ayala, 2018).

According to hydrology analyses run by Bolivia and Peru governments [historically, the period applied as a base line is 1965 - 2015], concerning the basins in the Pacific region, Locumba has a water availability of 9.32 m^3/s in average, Caplina 8.04 m^3/s, and Sama 2.15 m^3/s considering the areas of the basins under water use[1]. In the region of the international border between Bolivia and Peru the shared water availability from Maure, Uchusuma, and Caño rivers in Maure-Mauri basin in average is 7.05 m^3/s [4.24 from Mature, 0.84 from Caño and 1.97 m^3/s from Uchusuma rivers]. Finally, in the Desaguadero region at the downstream of the system, the water availability is estimated in 51.97 m^3/s at the confluence of Mauri and Desaguadero rivers [15.88 from Mauri and 36.09 from Desaguadero upper side] [2]. The upper side of Desaguadero river is dominated by the discharges of Lake Titicaca which is responsible to balance the streamflow from the north area of the altiplano region between Peru and Bolivia with a total average flow of 236 m^3/s and as a product of the lake water balance only 20 m3/s is release to Desaguadero river[3], this is a result of a complex interaction between the hydrographic system in the riparian areas around lake Titicaca related to agriculture and water consumption and also energy and mass balance of the Lake itself [evaporation is very relevant considering its area of about 8300 Km^2].

1.1.1.6. Mahanadi River Basin (India)

The Mahanadi is the 8th largest basin having total catchment area of 139681.51 Sq.km which is nearly 4.28% of the total geographical area of India. The geographical extent of the basin lies between 80°28′ and 86°43′ east longitudes and 19°8′ and 23°32′ north latitudes. It is physically bounded in the north by Central India hills, in the south and east by the Eastern Ghats and in the West by Maikala hill range. The basin is circular in shape with maximum length and width of 587 km and 400 km respectively. The catchment area of the basin extends over major parts of Chhattisgarh and Odisha and comparatively smaller portions of Jharkhand, Maharashtra and Madhya Pradesh states of India. (CWC, 2014)

The Mahanadi is a major river originating in Dhamtari district of Chhattisgarh and draining into Bay of Bengal. The total length of the river from origin to its outfall into the Bay of Bengal is 851 km. The Mahanadi basin is divided into 3 sub basins, namely upper, middle and lower Mahanadi. The Average annual runoff of Mahanadi is 66.9 BCM. Based on IMD data from 1974 to 2004 major part of the basin area receives rainfall from 1200-1400 mm. More than 90% of the total annual rainfall occurs during monsoon season spread over from June to October. The rainfall is not continuous but occurs in spells of varying durations and intensities. However, different blocks in 14 districts (5 of Chhattisgarh and 9 of Odisha) falling in the basin are drought prone (Ministry of Rural Development, 2002). (CWC, 2014)

December and January are the coldest months with the minimum temperature of 12° C. April and May are the hottest months in this region where maximum temperature ranges from 39° C to 40° C. As compared to eastern portion and delta area, western portions record the lowest and highest temperatures during winter and summer respectively. Highest day temperature recorded in the basin is 50.3° C in June, 2003. (CWC, 2014)

The average water resource potential of the basin is 66.9 BCM. The utilizable potential of Mahanadibasin is 50 BCM (Central Water Commission, 2013). In terms of water storage, the basin has total storage capacity of 14207.80 MCM. The water has been stored at many places and it creates few big reservoirs like Hirakud and Hasdeo bango. The ground water utilization is only about 4% of the utilizable potential (CWC, 1989). (CWC, 2014)

1.1.1.7. Murray-Darling Basin (Australia)

The MDB covers 1,059,000 square kilometers or 14% of Australia's land area, or an area bigger than Spain and France combined, with 84% of that land used for agriculture (where agriculture comprised 83% of total water use, industry 13%, and household use 2%). The Basin as a whole is responsible for approximately 52% of Australia’s total water use. Australia's three longest rivers, the Darling (2,740 km), Murray (2,530 km) and Murrumbidgee (1,690 km) are found in the MDB. Within those rivers, rainfall supplies an average annual of 530,618 gigalitres (or billion litres – GL). Of this, 94% evaporates or transpires, 2% drains into the ground, and the other 4% becomes run-off to river systems. Irrigation uses 65% of that water annually over 1.65 million hectares of land (2005-06 figures). Ecological status has improved with around 2,000GL of water rights being transferred to the federal government for use toward achieving environmental flows and goals—or roughly 20% of average annual water consumption in normal years. Some ecological status indicators have improved since 2008 when the recovery began, but other indicators require work (MDBA 2023). Monitoring and assessments of water flows, quality, use and environmental outcomes in the MDB are commonly undertaken by the Murray–Darling Basin Authority (MDBA) to update progress on national and state objectives, principally under the Basin Plan (MDBA 2012). Outlook for further quantitative improvement is currently stalled, especially in terms of adjustment mechanisms and their development such that further environmental recovery will be challenging and threats from future climate change may significantly undermine economic supply and ecological gains.

1.1.1.8. Orontes River Basin (Lebanon)

The annual flow of the Orontes River from Lebanon to Syria is 400 MCM, of which an agreement between Lebanon and Syria attributes 80 MCM to Lebanon. For years with an average discharge less than 400 MCM, the Lebanese side gets 20% of the discharge. The average annual temperature of the entire Orontes River Basin is estimated at 16 ºC. In January the average temperature of the basin can drop to -1 ºC, and in August it reaches 25 ºC, rising to 28 ºC. The Lebanese part of the basin receives an annual rainfall of 400 – 600 mm . The gauge flow measurements are restricted to 1931 – 43, 1955 – 74, and 2000 – present. According to data from Litany River Authority, mean annual flows in the Orontes River at Hermel station have decreased from an average of 13 m^3/s (413MCM/yr) over 1932–74 to an average of 10.6 m3/s (~330MCM/yr) for 2000–14.

1.1.2. Which is the qualitative (biological and chemical) status of water bodies?

Answer this question using data from river basin plans, in the case of the EU from the 3rd cycle RBMP.

1.1.2.1. Júcar River Basin (Spain)

The Júcar River Basin is subject to hydrological pressures related to water extraction and diversion of flow, mainly affecting the axes of the larger rivers. These pressures correspond mainly to dams and reservoirs that produce significant effects on the natural regime of the water bodies, as well as the diversions that are made from the numerous canals existing in the watercourse. The effective implementation of adequate ecological flow regimes is essential to avoid this impact to a greater extent. Regarding the pressures from alien species, in the case of rivers, the most widespread species and the one with the most knowledge is the common reed (Arundo donax), although there is a need to advance in the knowledge of other invasive species, although less widespread in the Demarcation, such as, for example, the Canadian poplar, which intensively occupies the margins of watercourses in the Teruel and Cuenca area, due to the high economic performance of its exploitation. Other invasive species that have also been detected are the zebra mussel, the Asian clam, the blue crab, the American red crab, the American mink, the turtle and the black-bass as animal species, and as plant species the water hyacinth and ludwigia. All previous pressures make the rivers in the Júcar River basin not present, in most cases, an adequate ecological status, which becomes even more evident after the publication in 2000 of the Water Framework Directive, in which a new approach is advocated in terms of management and use of rivers more in line with the principles of sustainable development and conservation of biodiversity, in order to achieve environmental objectives. One of the fundamental reasons for not achieving good status in water bodies is due to non-compliance with biological indicators (especially macroinvertebrates and fish), since, although there are physical-chemical and chemical non-compliances, these are minor. In the case of physical-chemical non-compliances, it should be noted that very important improvements have been made in water quality due to the implementation of Directive 91/271/EEC on urban wastewater discharges, although in some cases the low flows circulating in some water bodies may cause non-compliance with the physical-chemical quality of water, making it necessary to implement additional treatments to meet environmental objectives.

The Albufera Lake is located south of València and has an approximate surface area of 2,600 ha and is located within a Natural Park with a surface area of about 21,120 hectares, including both the lake of L'Albufera itself, as well as its area of influence. The Park has a large variety of habitats that allow the existence of a great global diversity of fauna and flora species. The natural and traditional values of L'Albufera de València are protected under different normative figures: Catalogue of Wetlands of the Valencian Community, Site of Community Importance (SCI according to the Habitats Directive), Special Protection Area for Birds (SPA according to the Birds Directive), list of Wetlands of International Importance RAMSAR and Natural Park. In addition, it should be noted that some parts of its territorial scope have been declared as "Microreserves of Flora" and as "Fauna Reserves". The competences related to L'Albufera are distributed among the local, regional and central administration.
The degradation of the waters of L'Albufera began in the sixties. The precarious state of the sanitation networks, accompanied by strong demographic growth, altered in this decade the dynamics of the marsh systems due to the entry of organic waste, detergents, pesticides or metals from intensive agriculture, industry and urban sanitation of the municipalities in its surroundings (Verdú et al., 1999), which until then had maintained a balance through a self-purification mechanism. At the same time, the agricultural activity associated with the rice fields that takes place in the wetland, has largely conditioned the economic, social, environmental, cultural, and even the water management linked to L'Albufera and has also a significant importance on the degradation of the system both from the point of view of quality and quantity of the water inputs to the lake.

Regarding water pollution, the high percentage of agricultural and livestock activity in the Demarcation entails important impacts on the water environment, both by withdrawal and by pollution. The problem of nitrates lies in the excessive use of fertilizers and to a lesser extent of phytosanitary products, causing the rise in groundwater (and in surface water) of nitrates, phosphates and pesticides. It has been a significant increase in these surpluses in the Júcar Demarcation in the last decade, which seems to coincide with the drop in prices that nitrogen fertilizers suffered, being 2008 one of the years in which these products peaked. According to the last RBP, in the Júcar Hydrographic Demarcation there are 22 groundwater bodies in poor chemical status due to the excessive presence of nitrates. Of the 22 masses in poor condition there are 10 masses in which a clear trend cannot be observed either upwards or downwards, while 9 masses present a downward evolution of nitrate values and 3 present a clearly upward evolution of nitrates concentrations. Although the problem of nitrates in groundwater is mainly linked to agricultural activity due to the use of nitrogen fertilizers, there are some water bodies in which the risk of nutrient pollution is not associated with the agricultural sector, but seems to respond to the pressure generated by the livestock sector, mainly the pig industry and the current management of slurry and manure.

1.1.2.2. Nitra River Basin (Slovakia)

Ecological status was very good and good in 41%, average in 45% , bad in 11% and very bad 3% of the rivers within the Váh RB. The ecological status/potential of the rivers within the Nitra river RB is mostly bad or very bad, except for the small tributaries with average or good status.
The chemical status/potential of Nitra river is not good from the spring to river km 164.45, while between the river km 161.45 - 168.50, the chemical status is good.

1.1.2.3. Reno River Basin (Italy)

Like most of the regional territory, the Reno basin is characterized by a mountain area that still has good natural characteristics and good quality conditions, an urbanized and fragile hillside area and a highly anthropized and artificial plain area.
The main pressures affecting the waters of the Reno basin are: point type pressure related to urban discharges and flood spillways, spread type pressures mainly related to the agricultural sector, and physical and hydromorphological alterations. Also, the impacts highlighted by the monitoring processes mainly relate to: nutrients, organic, chemical and microbiological pollution, as well as altered habitats due to hydrological and morphological changes.
The river water bodies identified under the WFD (Water Framework Directive) are largely natural (60%) in the mountain part, while from the foothills to the plain they are mainly heavily modified or artificial canals. Only about 30% of river water bodies, all natural and belonging to the hillside and mountain areas, have already reached the Good Ecological Status provided by the WFD, while 40% are in Sufficient Status and 30% in Bad Status. The Chemical Status, relating to the presence of particular priority substances, is mainly Good (about 85%).
There are also two lake water bodies which are strongly modified too, both in Good Chemical Status. Whereas, concerning the Ecological Status, one of them is in Good Status and the other one is in Sufficient Status.

1.1.2.4. Tympaki River Basin (Greece)

As previously mentioned, The Tympaki study area encompasses a basin of about 265 km2, and comprises according to the WFD typology, of 7 river water bodies, and 6 groundwater bodies.
As presented in the tables below, the chemical and ecological status of the surface water bodies is good, yet the chemical status of some of the groundwater bodies is poor. More specifically, 1 of the 6 groundwater bodies (EL1300082) is in poor chemical status, with significant pressures of over-abstraction for irrigation purposes, which has led to salinization and seawater intrusion, quantitative and qualitative deterioration. The other groundwater bodies are still characterized in good status, yet nitrate levels are found to be locally higher than the Maximum Acceptable Limits in different monitoring stations in 2 of these GWBs (EL1300081, EL1300086) reaching up to 60 mg/l in some locations, while local seawater intrusion is observed in the GWB EL1300250.

Lake water body (LWB) code	LWB name	Surface area (km2)	Ecological Status	Chemical Status	Monitoring Station Code	Monitoring Station Name
EL1340RL00204101H	Faneromeni	0.86	Good-High	Good	EL001300030030H500	Texniti Limni Faneromenis

River water body (RWB) code	RWB name	Length (km)	Basin surface area (km2)	Mean Annual Discharge (mio m3)	Ecological Status	Chemical Status
EL4001R000201017N	Geropotamos	3.68	15.21	45.51	Moderate	Good
EL4001R000203018N	Geropotamos	1.03	16.55	40.55	Moderate	Good
EL4001R000202122N	Geropotamos	5.21	12.82	4.22	Good	Good
EL4001R000202123N	Geropotamos	5.56	31.28	3.27	Good	Good
EL4001R000204124H	Geropotamos	7.1	13.19	9.88	Unknown	Good
EL4001R000204125N	Geropotamos	6.13	52.21	8.45	Good	Good
EL1340R000204126N	Geropotamos	6.49	29.46	3.05	High	Good

Monitoring stations of River Water Bodies				
Station name	Station code	River water body (RWB) code	Monitoring purpose	Station type
GEROPOTAMOS_DW	EL0013000400250100N500	Geropotamos-GR4001R000201017N	Ecological	Operational
GEROPOTAMOS_UP	EL0013000400250120N500	Geropotamos-GR4001R000205019N	Ecological	Operational
KUTSULIDI	EL0013000400250110H500	Geropotamos-GR4001R000204124H	Ecological	Operational

Groundwater body (GWB) code	GWB name	Basin surface area (km2)	Chemical Status
EL1300055	Porous system of Notio Rethymno	6.83	Good
EL1300065	Karstic system of NA. Psiloreiti	113.89	Good
EL1300081	Porous system of Tympaki Basin	28.69	Good, *local nitrates presence*

EL1300082	Porous Coastal system of Tympaki basin	6.3	Poor, *seawater intrusion*
EL1300086 (part of)	Porous system Messaras-Notiou Heraklіou	48.91	Good, *local nitrates presence*
EL1300250	Fractured System of Psiloreiti	60.39	Good, *local seawater intrusion*

Monitoring stations of Groundwater Bodies with local nitrates and/or seawater intrusion presence				
Station code	River water body (RWB) code	Monitorin g purpose	Nitrate levels	Chloride levels, local seawater intrusion
EL13071370	Porous system of Tympaki Basin-EL1300081	Chemical	High, above max acceptable levels	n/a
EL13081381	Porous system of Tympaki Basin-EL1300081	Chemical	High, 75% above max acceptable levels	n/a
EL13081344	Porous system Messaras-Notiou Heraklіou-EL1300086	Chemical	High, 75% above max acceptable levels	n/a
EL13061377	Fractured System of Psiloreiti- EL1300250	Chemical	Acceptable	High, above max acceptable levels

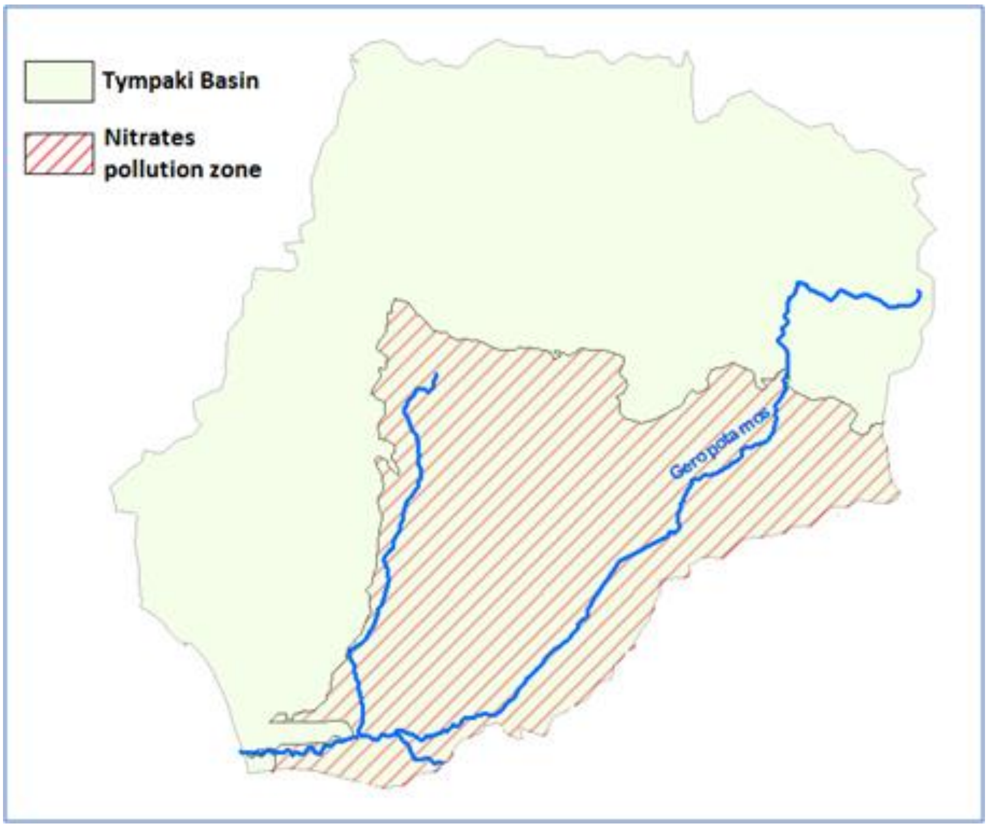


Figure: Extent of the nitares' pollution zone in Tympaki Basin in Greece

1.1.2.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

In several parts of this system, the deterioration of water bodies is evident due to the contamination of a wide variety of solid and liquid substances, such as effluents of domestic, agricultural, livestock, industrial, and mining activities, and in the case of the transboundary region of Maure – Mauri for the presence of volcanic activity specifically.

Bioaccumulation has been estimated in commercial fish species in Lake Titicaca and in 162 muscle samples. The results show the presence of cadmium, lead and arsenic in almost all samples. Mercury is found in fish samples taken in one area of the lake, although concentrations in water are above the admissible limit.(Comisión Multisectorial para la prevención y recuperación ambiental del lago Titicaca y sus afluentes, 2014), this may have an impact in the downstream area, in Desaguadero river considering the ecosystems linkage, but in terms of water quality the oxygenation along the river since Titicaca Lake to the areas related to the project may be admissible for economic activities such as agriculture.

In the upper basin, there is volcanic activity, which provides high concentrations of boron and arsenic to surface and groundwater. The presence of these metals restricts the use of water for domestic, agricultural and livestock activities. In the case of Maure basin, the contaminations source is located at Borateras – Calachaca area. The monitoring process from the local studies shows that in natural conditions the original concentrations in these sources of boron and arsenic reduce up to 6 and 7 times in the downstream area due natural purification considering the streamflow levels recorded in the hydrological monitoring network5. In this basin due to level of population which is very low in comparison to the pacific region of Tacna in Peru or Desaguadero in the downstream part of the system in Bolivia, the main contamination remains in this volcanic origin.

There are metal deposits and mining activity that releases heavy metals such as gold and silver. Substances such as manganese, antimony, and mercury have also been measured. High concentrations of thermotolerant coliforms have been measured downstream of human settlements, generated by the discharge of wastewater without or with insufficient treatment (Céspedes et al., 2007).

1.1.2.6. Mahanadi River Basin (India)

Surface water quality

According to data given in 'Integrated hydrological data 2012, CWC, the critical absolute values of water quality parameters for the Mahanadi basin exceeded the tolerance limit during the winter season of 2009-10. The prominent parameters which have crossed the tolerance limits frequently are Dissolved oxygen (DO) and Biochemical Oxygen Demand (BOD), with average values of 4.146 mg/L and 4.119 mg/L respectively for the Mahanadi Basin. The Mahanadi River basins have reported the tolerance limit for 11 water quality parameters only. (CWC, 2014)

Groundwater quality observations

There are 44 groundwater quality stations of CGWB in the Mahanadi basin. A total of 15 parameters are observed at these stations, which include BOD, DO, Magnesium, Fluoride, Nitrate, pH, Potassium, Sulphate, Electrical Conductivity, Total dissolved solids (TDS), Calcium, Sodium, Carbonate, Bicarbonate, Chloride, Sodium absorption rate, and residual sodium carbonates, etc.

The water quality data is not adequate, though the details of the location of observation wells may guide the reader about the possibility of data availability. (CWC, 2014)

1.1.2.7. Murray-Darling Basin (Australia)

Most major river systems now have good ecological status under water recovery (i.e. transfers of water rights from irrigators to federal government water holders), and delivery targets being met in recent years (MDBA 2023). Some smaller systems have more work to be done, and conflict between irrigation users and environmental delivery remains a potential source of conflict, especially during (potentially more frequent) drought periods. Economic concerns continue to dominate political focus and arguments for reduced change going forward, yet climate change pressures pose a distinct threat that remains outside current water sharing and planning arrangements between the federal and state governments, which regulate the MDB jointly (see states water sharing rules progress (ibid.)). Main quality issue remains salt: increased irrigation has mobilized significant quantities of salt into rivers and streams, lowering total quality. A salt management strategy has been implemented since the 1980s to deal with this via extractions of salty water, drying in evaporation ponds, and then storage across the Basin—at considerable national expense (MDBA, 2015, MDBA, 2014, Loch and Gregg, 2018). Past issues of black water (i.e. deoxygenated water) events, increased salt loads, blue-green algae and vegetative die-back during droughts have decreased in recent decades from these and other water delivery management and trade changes.

1.1.2.8. Orontes River Basin (Lebanon)

The available information on the qualitative status of the Orontes River Basin indicates that water quality at the headwaters is generally good but deteriorates in the middle and lower reaches of the river. A recent study shows that the major Ain Zarqa spring is clean, but upstream springs such as the Labwe were found to contaminated with E. Coli making it unsuitable for un-restricted irrigation and recreation. The quality of surface and groundwater in the basin varies, mainly according to the level of agricultural activity.In 2000, levels of major ions and trace metals found in the river in Lebanon mostly reflected the basin’s natural conditions. However, water quality is threatened by domestic wastewater discharge in many parts of the basin. Detailed information on water quality and environmental issues (biochemical oxygen demand, nutrients, heavy metals, electrical conductivity) are available for Syria and Turkey, but not Lebanon.

1.1.3. Which are the main water user sectors?

Answer this question using data from river basin plans, in the case of the EU from the 3rd cycle RBMP.

1.1.3.1. Júcar River Basin (Spain)

Irrigated agriculture 80%, urban water supply 16% (mainly the city of Valencia and its metropolitan area, and Albacete), industry around 4%.

1.1.3.2. Nitra River Basin (Slovakia)

The main water use sectors in the Nitra RB are energy production (coal power plants), chemical industry, and Nitrianske Rudno hydropower plant that together stand for 87.1% of the total water withdrawals. Other major sectors include water supply for the citizens and livestock production. These proportions will be most likely shifting as the coal mining is scheduled to cease by the end of 2023. At the same time, the mining company did not get support from the state to maintain the water drainage system and thus this groundwater source is currently unregulated and can not be fully used.

1.1.3.3. Reno River Basin (Italy)

Irrigation 80% (of which 83% from surface water, 17% from groundwater), Industry 12% (20% from surface waters, 80% from groundwater), households 8% (20% from surface waters, 80% from groundwater).

Data for the overall regional water use are the following: 61% agriculture, 25% household, 14% industry. Overall, 50% of this water comes from the Po river, 21% from Apennines rivers and 29% from aquifers.

1.1.3.4. Tympaki River Basin (Greece)

The main water use in the Tympaki study area is for irrigation (94.7%), while urban (4.5%), livestock (0.7%) and industry (0.03%) are the remaining water uses. In the central plain of Tympaki about 7.5 mio m3 are annually abstracted from 3 groundwater bodies (EL1300081, EL1300082, EL1300086-part of) for irrigation purposes, to irrigate about 40 km2. The "Faneromeni Reservoir" has been built in 2005 (storage capacity ~20 MCM) to cover irrigation water needs (in the wider plain of Messara including Tympaki). Although about 3 mio m3 are annually supplied from the Faneromeni Reservoir to the central plain of Tympaki, unmet demands still prevail. In the tables below we present the land uses per groundwater body and the annual water abstraction volumes from each groundwater body per water use sector.

Land Use in Tympaki study area per Groundwater body area					
Groundwater body (GWB) code	Urban	Agriculture	Pasture	Forest	Roads & Water bodies
EL1300055	0.6%	70.0%	22.7%	4.6%	2.2%
EL1300065	0.2%	3.80%	78.2%	17.0%	0.7%
EL1300081	3.4%	91.7%	1.4%	0.5%	3.0%
EL1300082	4.5%	72.4%	18.5%	1.9%	2.6%
EL1300086	0.8%	75.8%	19.8%	1.3%	2.2%
EL1300250	0.6%	47.4%	44.3%	5.5%	2.2%

Water Abstraction per sector in Tympaki study area per Groundwater body (GWB)						
Groundwater body (GWB) code	Mean Annual Recharge (mio m3)	Estimated Mean Annual Abstraction (mio m3)	Mean Annual Abstraction for **Irrigation** (mio m3)	Mean Annual Abstraction for **Drinking water supply** (mio m3)	Mean Annual Abstraction for **Livestock** (mio m3)	Mean Annual Abstraction for **Industry** (mio m3)
EL1300055	1.41	0.62	0.62	0.00	0.00	0.00
EL1300065	70.71	0.73	0.49	0.18	0.07	0.00
EL1300081	6.53	6.37	6.36	0.00	0.01	0.00
EL1300082	0.63	0.99	0.99	0.00	0.00	0.00
EL1300086	6.16	5.98	5.71	0.25	0.01	0.002
EL1300250	6.23	1.07	0.77	0.28	0.02	0.002
	SUM	**15.77**	**14.94**	**0.72**	**0.11**	**0.004**
	Percent (%) per sector		***94.73%***	***4.53%***	***0.71%***	***0.03%***

1.1.3.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

The resources of the basin are used by: 1) Peru: Water transfers in the upper basin to the Caplina region for irrigation and hydroelectricity of the Uchusuma system, to supply the city of Tacna and productive aspects (irrigation); 2) Bolivia: for productive issues (irrigation) specifically, in the departments of La Paz and Oruro, as well as the ecological requirements associated with the ecosystems that depend on these resources such as high altitude wetlands (bofedales) that are a source of food for camelid livestock present in the upper basin of the Mauri River and the lower part of the TDPS water system (Lake Titicaca, Desaguadero River, Lake Poopó, and Salar de Coipasa) (Comisión Técnica Binacional (CTB) de la cuenca del rio Maure –Mauri, 2019)

Under the water balances made by the agencies and national authorities, in the case of the Pacific Region, the water demand in Caplina, Sama and Locumba basin is estimated at 22.18 m3/s and the deficit reaches the 2.67 m3/s as a yearly average, but the most critic month is November [7.01 m3/s], from this demand 1.59 m3/s on average is covered by the water transfer from Maure Basin and the projection of water availability for the region suggest the increase in this water transfer due to more critical water scarcity in the pacific region in the near future.

In the region of the international border for Maure-Mauri basin, there is no water use for socioeconomic activities beyond the local requirements of the communities, this is because climate, agriculture in general are not feasible in this area. Moreover, the basin holds very sensitive ecosystems such as wetland of high altitude [bofedales] which support endogenic activities of the communities related to native species such as camelids [alpaca, llama among other wildlife]. These small activities in addition with the environmental implications of water use considering water transfers, streamflow reductions and effect on local bofedales, and the water bodies in Desaguadero downstream is not quantifiable with the current data or studies [one example is lake Poopo which disappeared in the hydrological season 2014/15 due to climate and other factors6]. Finally in the region of Desaguadero the main economic activity is intensive agriculture with a total water demand of 8.38 m3/s, the most critical month in

November with a demand of 23 m3/s. All this water demand and water deficits are compiled in WEAP models for each part of the systems which may require updates in the case of the use for the project.

1.1.3.6. Mahanadi River Basin (India)

According to the data from 2017, 23.24 BCM (36.5 per cent of the utilisable water) is consumed by domestic, agriculture and allied sectors, of which 65 per cent is met from surface water while 35 per cent is the contribution of groundwater.

Water use/requirement of sectors	Current Estimated Use (BCM)
Domestic	3.87 (1.16 SW & 2.71 GW)
Livestock	0.54 (0.27 SW & 0.27 GW)
Irrigation	18.82 (13.72 SW & 5.10 GW)
Industry	2.07
Environment	16
Total	41.30

Out of the total surface water bodies present in the basin, 95.87% of water bodies are tanks. There are reportedly six major reservoirs in the basin where the area is greater than 2500 ha, namely Hirakud reservoir, Hasdeo-bango, Ravishankar sagar, Indravati, Tandula, and Dudhwaha. The water of Hirakud is allocated to irrigation, hydroelectric, drinking, and industrial purposes. (Samuel et. al, 2017)

1.1.3.7. Murray-Darling Basin (Australia)

Agriculture and environmental watering remains the major water use at around 83%, followed by industry and electricity generation (13%), and household consumption (2%). Other uses include conveyance water and losses which remain tricky to calculate accurately.

1.1.3.8. Orontes River Basin (Lebanon)

Agriculture (irrigation), domestic and to a lesser extent industrial. The total irrigated area in the basin is estimated to be 300,000 – 350,000 ha with only 6% in Lebanon. In Lebanon, total water use is estimated at 21 MCM/year of which around 23% is used for domestic purposes and the rest for irrigation (where most of the land is irrigated by wells). These estimates refer to the northern section of the Orontes, downstream of Ain Zarqa Spring, excluding the entire topographic catchment (including agricultural areas around Labweh, Al Ain, Ras Baalbek and El Qaa).

1.1.4. How is climate change projected to affect water quantity, quality and water use?

Answer this question using data from river basin plans, in the case of the EU from the 3rd cycle RBMP. Specify how projections vary across different future emissions scenarios and time periods.

1.1.4.1. Júcar River Basin (Spain)

Water resources in the Júcar River Basin will be reduced by climate change according to most projections. Some areas could see a 40/50% decrease compared to the late 20th century level, depending on the source. The upper part of the basin, where most reservoirs are located is expected to experience the largest reductions. This could affect the interannual storage needed to cope with droughts. The percentage of decrease is uncertain, but most CMIP5 projections agree on a reduction of 25/50%, so the confidence level is high. Moreover, future drought indices projections indicate more frequent and severe droughts, which will challenge the water use sustainability in the system. This decrease will have impacts on all water uses: urban supply, agriculture, hydropower, and environmental status. Agriculture and environment are expected to be the most affected. Agriculture has an 80% share of total water use and lower priority than urban supply, so it will face the biggest water delivery curtailment among consumptive uses. The environmental status of water and dependent ecosystems will also be challenged by lower streamflow and competition with agriculture. Hydropower production may also suffer a significant decrease, but it is expected to be lower than in the previous sectors. According to the Júcar River Basin Management Plan of the JRB district, 53% of their natural river reaches will not reach a good status before 2027 as required by the WFD. Likewise, all heavily modified or artificial reaches will not reach a good status. The situation is better for reservoirs, with 86% expected to show a good status by 2027, but it worsens for natural lakes (63%) and even more for heavily modified or artificial lakes (50%). The overall evaluation of surface bodies shows that 52% will not reach the good status by 2027 required by the WFD. The situation of groundwater bodies is similar, since 46% will not reach a good status before the original deadline of the WFD. This situation is combined with a heavily committed basin in terms of water resources, since consumptive water demands account for 95% of the average surface water resources.

1.1.4.2. Nitra River Basin (Slovakia)

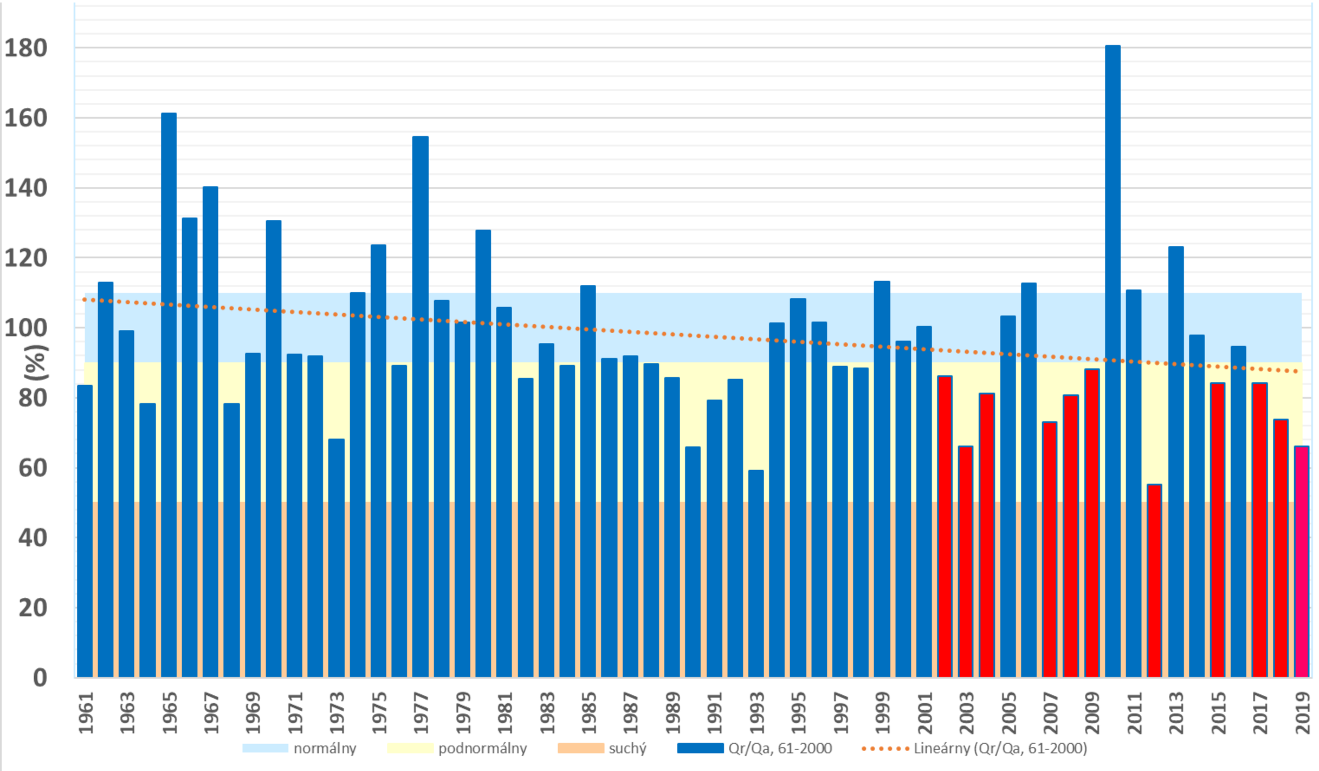
The annual temperature has increased by 1.1°C in the last 100 years and is expected to increase by 2 – 4 °C by 2075.

Annual precipitation is expected to decrease by about 10% by 2075 - 2100 according to some models, while the precipitation distribution will become temporarily and spatially less even (Faško et al. 2022, 2023). Water resources are expected to fall by 30 - 50% (RBMP, 7th National Report on Climate Change, 2017). Different climatic scenarios indicate shifts in the long-term average annual runoff in most areas of Slovakia, with a more pronounced decline expected in the lowlands in the southern and western part of the country. The long-term average monthly flows are expected to decrease between February and November with most pronounced decreases between May and July, in some cases, -70 % declines by 2075 may be expected.

According to the scenarios, significant decrease of snow cover in the winter and earlier snow melting in spring can be expected, which has been already observed (Faško et al., 2022, 2023; Pecho et al., 2018. On the other hand, lower precipitation and high temperatures during the summer and autumn months are expected, which in turn will result in very low soil moisture and subsequently long-term droughts. These dry periods are expected to be interrupted by intense storms with heavy precipitation . Although the number of storm days is not expected to change significantly (15 - 30 during summer), the frequency of heavy storms is expected to increase by up to 50%. Even tornadoes may occur in Slovakia. With higher frequency of intense storms, more frequent flash floods can be expected locally. SHMÚ is preparing new climate scenarios for Slovakia that should provide more precise projections.

Mountains surrounding the Nitra RB are composed of tectonic rocks (andesite) overlaying coal deposits and soft sedimentary layer, which caused the tectonic blocks to collapse at many places and created several km-long trenches. Precipitation seeps into the groundwater through these trenches. In addition, this geological preconditions were accelerated by the extensive coal mining activities. Given the complex geology, water scarcity issues will likely be exacerbated by the climate change.

Observations from the last two decades indicate an increase in hydrological extremes. Some of the years were water-rich (2006, 2010, 2013), while other years were very dry (2003, 2007, 2012, 2018, 2019). Period of 2010 - 2016 was extreme in terms of hydrology, which provided a lot of insights in terms of floods and droughts. Although monitoring of runoff and groundwater resources indicated some shifts in water regimes, annual runoff patterns did not change substantially. Between 2010 - 2019, there were 6 years without spring peak flow in most river basins. The water content (?) has decreased between 1961 - 2019 relative to the reference period 1961 - 2000 (Fig. 1.1.4.2)



The trends in the past decades suggest spatial variability of shifts in the hydrological regimes and that the shifts in the northern part (and higher elevations) differ from those in the southern part (lower elevations) of Slovakia.

Monitoring of groundwater level wells during 2010 - 2016 suggests decreased groundwater reserves in nearly 80% of the lowlands and basins in Slovakia between 1981 - 2016 compared to the reference period (before 1980). The average declines of specific groundwater reserves in all the 10 sub-basins was around 20,000 - 40,000 m^3/km^{-2} between 1981 - 2016. The largest decreases (80,000 m^3/km^{-2} on average) were observed in Hron and Slana RB.

Declines in water resources, more extreme floods and droughts, runoff regime shifts suggest that climate change impacts on hydrology is one of the main sources of uncertainty in water resources management.

1.1.4.3. Reno River Basin (Italy)

Water stress may increase by 25% in this century as a result of growing irrigation demand. For the 2041-2070 period discharges fall from May to November and remain constant the rest of the year. For 2071-2100 projections, discharge reduction from May to November persists and is more severe than in the preceding period and increases up to 60% the rest of the year. Minimum flows and dependent water allocations in Italy are expected to be reduced by up to 40% by the 2080s.

1.1.4.4. Tympaki River Basin (Greece)

Crete has a typical Mediterranean island environment, and the Tympaki climate is classified as dry sub-humid according to UNCED definitions. Rainfall in the Tympaki area is very low, less than 500 mm per year. The resultant moisture index Ih of 0.532, is in turn very low, bordering semi-arid conditions. Despite these unfavorable climatic conditions, the basin is the locus of intense agricultural activity. Evaporation losses are high, while the average rainfall infiltration for the elevation zone 0-100m is 28 mm per year, for the zone 100-200m is 38 mm per year and for the zone 200-300mm, 56 mm per year. Streamflow infilltration constitutes the main source of groundwater replenishment of the Tymbaki central plain. The mean annual infiltration through the Geropotamos alluvium is estimated around 4 mio m3.

The overexploitation of groundwater has reduced water availability, while the uncontrolled pumping and use also creates tensions amongst the users. Soil degradation and salinisation are also important issues of the wider area, while desertification in becoming an issue as well. Simulation of seawater intrusion, has established that at the southern end of the coast, by the Geropotamos stream alluvial recharge zone, the toe of the saltwater intrusion front lies 550 to 600 m inland from the coastline. At the northern end of the coast, at the Makrymaliana area, the toe of the saltwater intrusion front is located 1500 m from the coastline. This apparent differential behavior of seawater intrusion between the southern and northern part of the coast, is attributed to the effects of the Geropotamos infiltration recharge. With infiltration amounting on average 4 Mm3, 36% of the total recharge, Geropotamos river is by the far the most important water supplier to the Tymbaki aquifer and as such, regulates the seawater intrusion extent and pattern. During favorable hydrological conditions, the trend of the seawater intrusion pattern below the Geropotamos recharge zone is reversed.

Climate change impacts in the Tympaki basin water budget were investigated as part of a wider study in Crete Island, which examined the impact of different climate scenario on the hydrological balance. The reference period used (baseline) was 1983-2009, and the scenarios looked at the future period 2060-2098. The following scenario assumptions were used:

- Temperature increase (from 16.1 degrees C in the baseline) by 0.7-3.1 degrees C, i.e. by 4% to 29%
- Reductions in rainfall by 4% to 29%
- Reductions in spring discharges (in the mainland) by 1.5% to 32%
- Reduction in the surface runoff by 2% to 38%

- Increase in irrigation water demand by 2.5% to 15%

The most recent Regional Plan for Adaptation to Climate change in Crete (PESPKA, December 2021) simulated climate change conditions in Crete using EURO-CORDEX RCMs (CCLM4-8-17, HIRHAM5, RAMCO22, RCA4) downscaled for Crete, for Scenarios RCP 4.5, RCP 8.5. The reference (baseline) period was 1980-2022, while estimates of changes in meteorological parameters were simulated for the future periods 2021-2040, 2041-2006 and 2081-2100. The following simulation results were obtained for some indicative parameters (average values0 and for the scenario RCP 8.5:

- Increase in mean temperature: 2021-2040: +1.38 oC; 2041-2080: +2.22 oC; 2081-2100: +4.36 oC;
- Reduction in mean annual rainfall: 2021-2040: -36mm (or -4.9%); 2041-2080: -88mm (or -12.8%); 2081-2100: -187mm (or -27.1%)
- Reduction in mean annual rainfall: 2021-2040: +5.1days; 2041-2080: -+12.7days; 2081-2100: +25.7days
- Increase in drought duration (consecutive days with rainfall < 1mm): 2021-2040: -36mm (or -4.9%); 2041-2080: -88mm (or -12.8%); 2081-2100: -187mm (or -27.1%)

Natural water resources' availability, both groundwater and surface water, is also decreasing due to climate change trends. Changing precipitation and ET patterns drive changes in the springs' outflows, as well as in the crop water needs, and lead to increased water demands in the urban (and agricultural sectors, which cannot be met by the current water supply and infrastructure. It is clear that climate change has an impact of the Geropotamos river flow, with a cascading negative effect on the recharge of the Tympaki groundwater bodies and the regulation of seawater intrusion. Robust climate change scenarios and forecasting are necessary for better planning of measures and water works and better adapting to future climate change uncertainties. Adequate climate-resilient measures are necessary to restore groundwater levels to sustainable levels, comply with the groundwater aquifers' sustainable yields, maintain environmental flows in the rivers, as well as improve the chemical status by containing and reducing nitrates pollution.

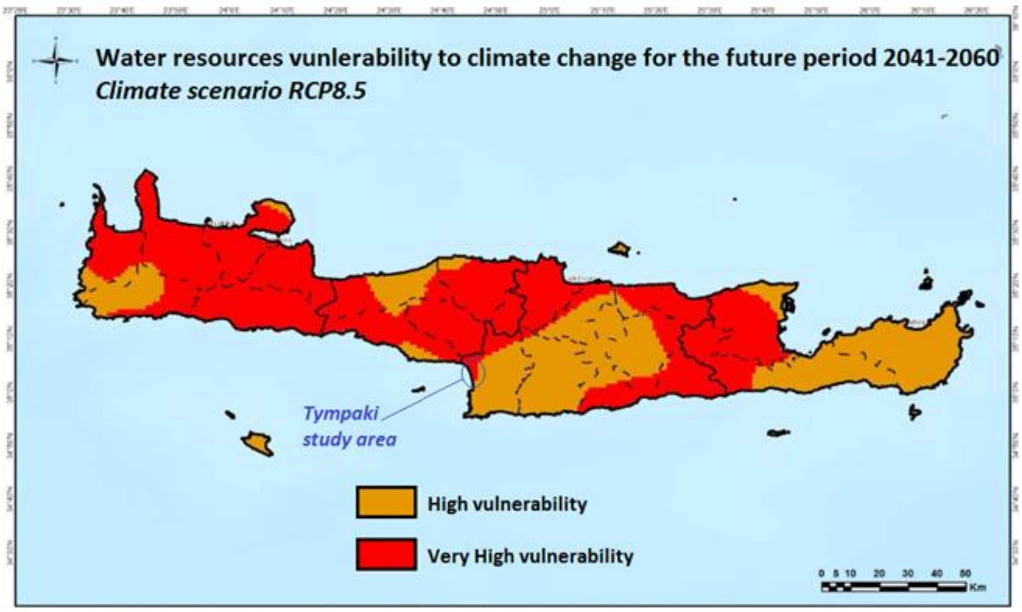


Figure: Water resources vulnerability to climate change for the future period 2041-2026, using climate change scenario RCP8.5. Source: Region of Crete, 2021. Regional Plan for Adaptation to Climate change in Crete (PESPKA), December 2021.

1.1.4.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

There are no specific studies of climate changes in the basins for the systems related to the project, however, there area regional and national official scenarios that may define projections of future climate conditions, however these scenarios are not applied to hydrology or any other planning tool at basin level yet, from stakeholders, but there are some in the academic community as a scientific evaluation.

The spatial distribution of projected precipitation changes for the period 2036-2065 shows a large spatial variability across the complete region, with reductions and increases between -15 to +15%, especially at the annual level and for the wet period [DJFM]. The results suggest increases in the center and northwest of the system and reductions in the south [Desaguadero and Maure regions are located at the south]. Most of these changes, however, are not statistically significant. On the other hand, in the dry period the results show signs of precipitation changes ranging from -30 to +30% across the basin with small regions with larger and statistically significant changes, especially east of the TDPS.

In the case of maximum temperature, projections suggest a generalized increase throughout the TDPS system. These increases present a spatial gradient, since around Lake Titicaca the changes are smaller and increase as one moves away from it. Annual scale changes are between 3.1ºC to 3.6ºC, in the core wet (warm) period [DJFM] between 2.7ºC and 3.1ºC, while in the core dry (cold) period [MJJA] the projected increase is higher, between 3.2ºC and 4.4ºC. The changes are well above the natural variability, indicating that the projections robustly indicate a consistent and progressive increase in maximum temperatures for the period 2036-2065.

Finally, changes in minimum temperature also showed increases throughout the TDPS region with values ranging from +1.3 to +2.5°C for the annual scale. For the core of the wet period this range is +1.4ºC to +2.6ºC and, for the core of the dry period, it corresponds to +1.0ºC to 2.4ºC. These changes are clearly smaller than those of the maximum temperature, and are also above the observational variability, so it is concluded that these increases in the minimum temperature are highly probable for the middle of the century.

1.1.4.6. Mahanadi River Basin (India)

According to Panda (2018), an analysis of instrumental climate data has revealed that the mean surface temperature over India has increased at a rate of about 0.4 degree Celsius per century, which is statistically significant. While in the year 1999-2000, the minimum and maximum temperature of the basin ranged between 7 and 45.5 degrees Celsius, it went up to a range between 13 and 48.8 degrees by 2012. According to Ghose et.al (2016) the water yields show decreases of more than 10% for the Mahanadi. This is mainly because of a significant decrease in rainfall.

A WEAP (water evaluation and planning) model has been set up by Kumar and Bassi (2021) to analyse the impact of rainfall on surface flows of Mahanadi river basin. The model showed that there would be a water deficit, about 1,684–2,373 MCM in 2050 due to an increase in supplies owing to an increase in the catchment yields resulting from higher rainfall.

While there will be a significant amount of outflow from the two sub-basins in all the scenarios in most future years (ranging from 25,286 MCM to 28,697 MCM in 2050), during drought years, the water deficit in the upper basin areas will increase slightly, but with a significant reduction in the outflows to the lower sub-basin areas by 2046–47 (will be about 11,311 MCM).

1.1.4.7. Murray-Darling Basin (Australia)

This remains unclear for the MDB, which would be common for many river systems and catchments. Early studies of climate change impacts on the MDB reinvestigating earlier studies performed by CSIRO (1996) and others (e.g., Chiew et al., 1995) predicted large climate variability, increased water use as a proportion of total streamflows and competing demands for water over time. Rainfall could either increase or decrease, but temperature and evapotranspiration are expected to rise especially in any region where rainfall decreases. Evaporation from storages was also expected to increase (Jones et al., 2002).

By 2030, the risk of exceeding drought condition thresholds increases from 1% to 30%, and by 2070 the probabilities increase again to 60-70% for drought-dominant regimes, and 10-20% for flood-dominant (ibid.). In 2008, Quiggin et al. (2008) showed that following either a 'business as usual' approach scenario, or experiencing dry scenario outcomes in the MDB would both result in reduced economic returns out to 2100; effectively making irrigated agriculture in the Basin infeasible. In summary, these reports found that: i) drought and severe drought conditions will become increasingly common; ii) impacts out to 2030 are uncertain but surface water availability is highly likely to decrease especially in the sMDB (expected 13% decline); iii) in volumetric terms most impacts will be experienced by environmental rather than consumptive users; iv) groundwater extractions may increase to represent around 25% of use by 2030; average surface water availability may decrease by 4% over the Basin under current sharing arrangements but by up to 50% in dry conditions within the Victorian regions; v) with larger impacts on low and general security products relative to high security rights; and vi) high uncertainty surrounding total reductions out to 2030 which could see either a 34% decrease or 11% increase in average surface water availability.

Much has been made of the relevance that the MDB Plan (MDBA 2012) will play in mitigating climate change impacts in southern Australia, where scenarios suggest a range of surface water availability outcomes spanning a 7% increase to a 37% decrease by 2030 (Pittock and Connell, 2010). The Plan's response involves immediate action to recover additional water for the environment which, combined with refinements to existing water sharing arrangements, would buffer the system from stress under a drying climate (MDBA, 2019). The Plan is also supposed to consider climate projections involving a continuation of deep droughts, if not an increase in drought events in future (ibid.), and some analysts suggest that the MDBP is achieving tentative steps toward integrated adaptive management in the face of climate change (e.g., Allan et al., 2013).

Given that IPCC (2018) predictions regarding climate change impacts at 1.5°C warming on social, economic and environmental sectors may be reached in the next 20, 14 or 10 years respectively given probability distributions for outcomes, a delay in addressing the climate change problem poses substantial risk to human welfare (Goulder, 2020). However, uncertainty with respect to down-scaled (i.e. localized) climate impacts and appropriate adaptation strategies for water users remains high.

We recently conducted an analysis of progress toward modeled climate change impacts since 2008, when the Garnaut Review on Climate Change Impacts was conducted (Garnaut, 2008). As shown in the Figure below, the original pathways developed by Quiggin et al. (2008) continue to buffer those modeled predictions and suggest a steady decline out to 2100 and significant reductions in water supply if no change is undertaken.

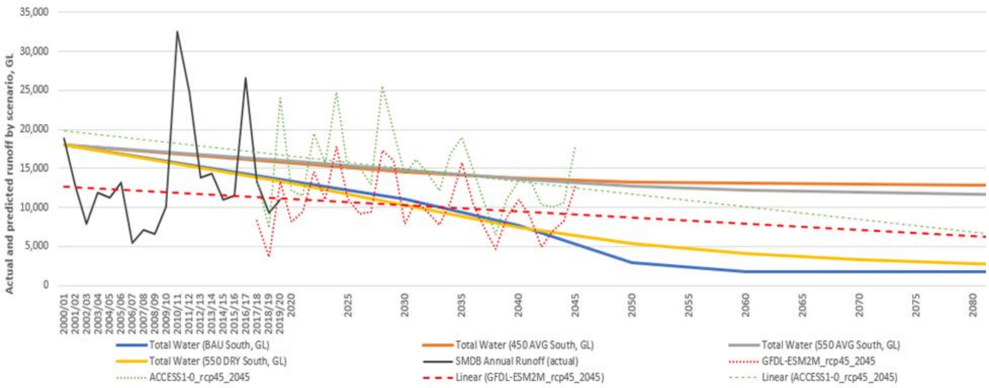


Figure 3: Garnaut climate change scenarios, actual runoff (2000-2020) and study climate model runoff predictions (2021-2080) for sMDB based on last 20 years climate history and CSIRO / BoM RCP45 scenarios.

1.1.4.8. Orontes River Basin (Lebanon)

Projected changes in water availability and quality in Lebanon carry a significant level of uncertainty. Climate change projections indicate a potential rise in temperatures of up to 3.2°C and a decrease in precipitation by 4% to 11% by the end of the century. These anticipated impacts of climate change include a 29% reduction in water availability by 2080, a decline in agricultural activity, and an increase in the frequency of droughts and floods.

2. Water allocation and economic instruments

This section presents for a set of countries the water allocation system - the set of laws, rules or common practices that determine who is able to use water resources, including how much they can abstract, for what purpose, and when and where withdrawals are permitted.

2.1. Legal water management framework

2.1.1. How are water rights defined and regulated?

Are water rights defined as a total volume or a shared of available resources? Are rights public or private? What law(s) regulate(s) water allocation? Is water bundled to land? What are the type of uses, and the priority of access to water among them? Can rights be carried over in time? What institution allocates and manages water rights? Is there a requirement for metering? Identify key barriers and challenges hampering water rights performance.

2.1.1.1. Júcar River Basin (Spain)

Water resources in Spain are owned by the public and licenses for the use of surface water are granted for a period of 30 years according to the 2001 Water Act (based mostly on the 1985 Water Act, with slight modifications). Water rights can be bundled or unbundled with land, depending on the situation.

For those rights under 7000 m3/y, and in the case of irrigation, water is bundled with land (bundled rights). The quantity of water is defined as total volume, and there are no security levels associated with these rights (guarantees are calculated with different thresholds for sectors – and this is related to costs). There is a clear priority of use for water in Spain, with households and environment having the highest priority (though also allowing for the reduction of environmental flows during droughts), followed by industry, irrigation and agriculture, with ligneous trees being given a higher priority within the agricultural sector. The Water Law establishes that water users must install meters and report their water use to the competent authority on a regular basis. The Water Law also establishes that water tariffs must cover the costs of water services, including the costs of water resources management, water supply, sanitation and environmental protection. Water rights can be carried over in time as long as the conditions of the concession or authorization are met and there is no change in the use or location of the water resource.

Some of the key barriers and challenges hampering water rights performance in Spain are: 1) the lack of coordination and cooperation among different administrations and stakeholders involved in water issues; 2) the existence of illegal or unregulated water abstractions, especially from groundwater resources; 3) the insufficient enforcement of water rights and sanctions for non-compliance; 4) the low level of public awareness and participation in water governance; 5) the impact of climate change and droughts on water availability and quality.

2.1.1.2. Nitra River Basin (Slovakia)

Water resources in Slovakia are owned by the state according to the Constitution of the Slovak republic (Title 1, Article 4). The permits for water rights are granted by the local authority, which is usually the district authority. Water rights are granted for the max. of 10 years and the granting process is defined in the Water Act No. 364/2004 Coll. Permits are granted for drinking water, drinking and sanitary water for livestock, irrigation, energy production, and other uses (e.g. technological water for industries). The permits can be usually extended if the conditions under which the permit was originally granted, do not change. The amount of water withdrawn is subject to notification obligation as defined by the Water Act. The amount and quality of water as granted by the permits for energy production from the surface or groundwater is not guaranteed. The water authority granting permits is bound to maintain minimum water flows, which are sufficient for functioning of the water courses and aquatic ecosystems. In case of groundwater sources, the Ministry of Environment defines the safe ground water level ensures sustainable use of groundwater. This level set by the Ministry is not required for household wells and specific use if the sum of the abstraction does not exceed 15 000 m^3 annually or 1250 m^3 per month.

2.1.1.3. Reno River Basin (Italy)

Water resources are owned by the public. An abstraction license is required under the Royal Decree (R.D.) n° 1775 of 1933 for the abstraction of surface waters (such as from rivers, streams and canals) and groundwater. Since then, the regime has evolved through a process of political decentralization and devolution of environmental protection. As a result, the regional administrations have gained full jurisdiction over water allocations. The transposition of the EU WFD in Italy has prompted a number of legislative and institutional reforms, in which include the 2006 Environmental Code (Legislative Decree 152/2006).

Licenses are granted according to the different uses and at most for 40 years in the case of irrigation and 30 years for other uses, , although regional laws may specify otherwise. Type of uses include Irrigation, potable, civil, indisutrial, fish farming, energy, sanitation, zootecnic, others, with the following priority: 1. Household, 2. Irrigation, 3. others, modified in 1980 to include environmental flows. Water rights cannot be carried over. Water rights can be bundled or unbundled with land, depending on the situation. The quantity of water is defined as total volume and derived flow rate, without prejudice to compliance with the Ecological Flow . In Emilia Romagna where most of the Reno Basin is located, new licenses are required to include metering devices.

2.1.1.4. Tympaki River Basin (Greece)

Water services are controlled by the state. The Directorate of Water in the Decentralized Administration of Crete (WDC) is the competent authority, which issue licenses to conduct water exploitation works of surface or groundwater resources (e.g. wells, dams, etc.) and to abstract water resources. The relevant legislative framework is included in the 146896/2014 Joint Ministerial Decision. The water uses for which a license is required are mainly water supply, agricultural use, industrial use, energy use and recreational use, in accordance with paragraph 1 of article 10 of Law 3199/2003. Water uses are listed indicatively by category in Annex I of the JMD 146896/2014. According to the Joint Ministerial Decision 1958/2012 (Annex II) the water works, hydraulic works and water resource utilization activities are classified in different categories/types, namely category A (with subcategories A1 and A2) and B. Different requirements apply for issuing a permit to implement the work and for obtaining a water use license depending on their category, and usually involve an approval of the environmental conditions met, and/or compliance with standard environmental commitments, and compliance with the existing River Basin Management Plans (RBMPs). The duration/validity of the water use licenses follows the revision cycle of the Management Plans and thus expires within one year after the RBMPs are revised.

The management of potable water is conducted by Public Water Supply and Sewerage Companies (DEYA) which are municipal enterprises or the municipality itself in case of smaller municipalities. DEYA undertakes the potable water supply as well as the collection and treatment of urban waste water. In case of irrigation water, usually there are Local Land Reclamation Organisations which are abbreviated as TOEV, otherwise the municipality itself is playing this role. The Region of Crete controls TOEV's financial status. In the Tympaki River Basin the TOEV of Zone A' of Messara is active, as well as DEYA Faistou, which is the local municipal enterprise. However two more TOEVs exist (TOEV of Zone B' and Zone C') which manage the irrigation water in neighbor areas of the Messara plain west and central part. In case that DEAY or TOEV cannot supply a user with potable water or irrigation water (citizen or farmer respectively), a private license to construct a well and subsequently to use the water resources can be granted by the WDC, taking into account possible restrictions which exist in the specific area according the River Basin Water Management Plan of Crete (RBMP of Crete) as well as the 5656/2015 Decision of the General Secretariat of the Decentralized Administration of Crete. Water use licenses are granted for a time period which is connected to the RBMP validity time.

Water rights can be carried over. Water rights can be bundled or unbundled with land, depending on the situation. The quantity of water is defined as total volume, and there are no security levels associated with these rights. However, in case of a drought, restrictions can be issued by the competent authority. The Region of Crete is monitoring water levels (since 1980) and if levels fall below defined thresholds restrictions on issuing new licenses (e.g. minimum distance between existing and new wells) may be applied.

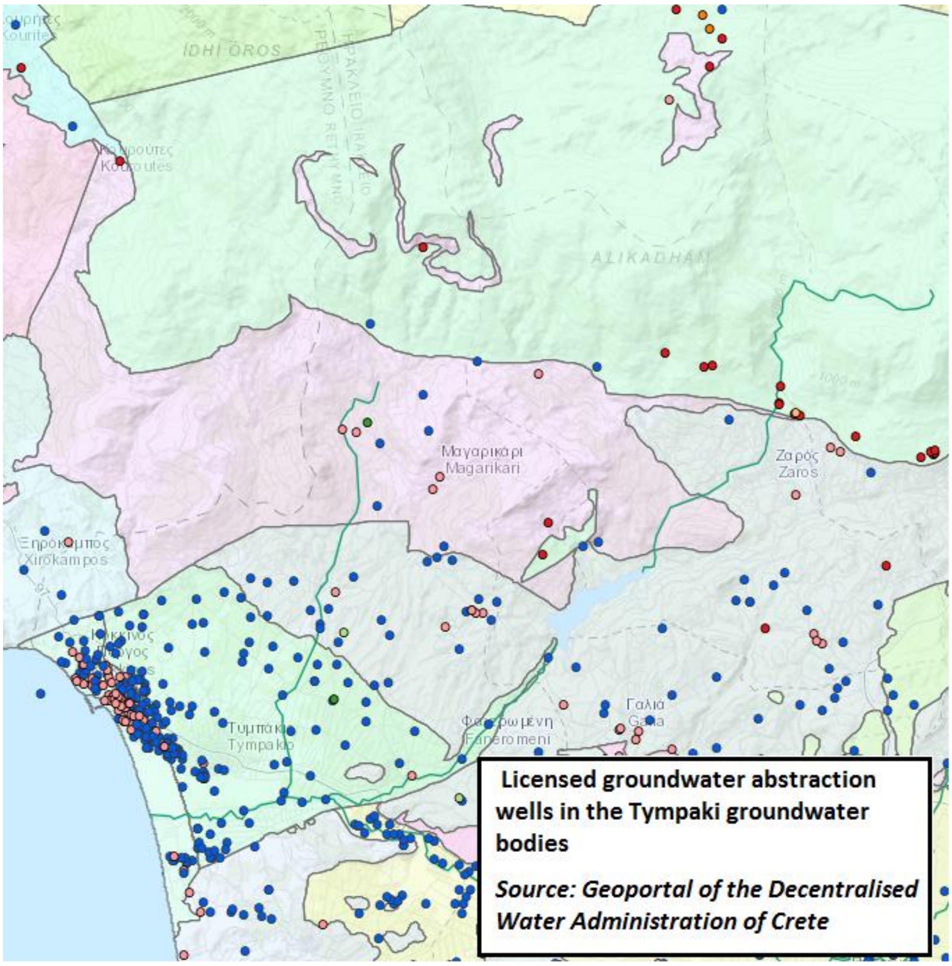


Figure: Licensed groundwater abstraction wells in the Tympaki groundwater bodies
Source: Geoportal of the Decentralised Water Administration of Crete (https://geoportal.apdkritis.gov.gr/gis/home/webmap/viewer.html?useExisting=1&layers=7282529557044b5aa527bb1d18b21a51)

2.1.1.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

Each country in this transnational riverbasin has its own law about water rights. However, there is a binational agreement in place that determines the maximum amount of water that each country can use from the Mauri River: Peru-Chile can use 10m3/s and Bolivia 10m3/s. Above this maximum value the countries allocate water rights independently (Molina et al., 2014)

Perú: On March 30, 2009, the Law on Water Resources, Law No. 29338 (hereinafter the LRH) came into force; with it, a new legal system was established in Peru that expressly grants water the status of public hydraulic water property, and develops an institutional, rights granting, economic and protection regime for the water. Water and the natural assets associated with it constitute public hydraulic water domain goods. Any intervention by private parties that affects or alters the characteristics of these properties must be previously authorized by the Water Management Authority (AAA by the Spanish Acronym), except for the primary use of water and those related to navigation.(Pinto, 2018). Water permits allocate a total volume of water that each user can capture in a year. In basins where the water source has been declared depleted (use has reached the maximum allowable), no more licenses are granted.(Huanacuni & Cambillo, 2023).

Bolivia: There are regulations in place, like article 298 from the Bolivian national constitution related to the General Regime of Water Resources and its Services, there are water authorities by sector which are in charge to monitor and check the proper use. The monitoring process is run by semester and yearly reports by the users which are compulsory to update the licenses the government grant through the sectorial water authorities, their jurisdiction however is national and regional [states], which mean at the local or basin level, there is no regulation in place yet and the allocation is no evaluated through integrated planning process. From the point of view of water rights and their representation at this level, water is allocated by headwater priority, upstream communities can draw water from the river until their needs are met, and downstream communities use the remaining flow.

Chile: Water is a national asset for public use, according to the Civil Code of the 19th century. However, the national constitution defines the Water Development Rights (DAA), which function as perpetual concessions for the use of water for the agricultural, industrial, or sanitary sector and are granted free of charge. The national entity in charge to monitor the situation of water availability and water demand is General Direction of Water [DGA by its name in Spanish].

2.1.1.6. Mahanadi River Basin (India)

In general, water law is largely state based in India. This is due to the constitutional scheme, which since the Government of India Act, 1935 has in principle given power to the states to legislate in this area. Thus, states have the exclusive power to regulate water supplies, irrigation and canals, drainage and embankments, water storage, hydropower and fisheries. There are nevertheless restrictions with regard to the use of inter-state rivers. Further, the Union is entitled to legislate on certain issues. These include shipping and navigation on national waterways as well as powers to regulate the use of tidal and territorial waters.

The Constitution also provides that the Union can legislate with regard to the adjudication of inter-state water disputes. While no substantive clauses could be adopted at the time of the adoption of the Constitution, a specific act, the Inter-State Water Disputes Act was adopted in 1956. This introduces a procedure for addressing disputes among states concerning inter-state rivers that have not been solved through negotiations. It provides for the establishment of specific tribunals to adjudicate such conflicts and has been used in several cases.

Parliament also enacted the River Boards Act, which provides a framework for the setting up of river boards by the Central Government to advise state government concerning the regulation or development of an inter-state river or river valley. River boards can advise state governments on a number of issues including, conservation, control and optimum utilisation of water resources, the promotion and operation of schemes for irrigation, water supply or drainage or the promotion and operation of schemes for flood control. This act has, however, never been used in practice.

While the intervention of the central government in water regulation is limited by the constitutional scheme, the importance of national regulation in water has already been recognized in certain areas. Thus, with regard to water pollution, Parliament did adopt an act in 1974, the Water Act. This act seeks to prevent and control water pollution and maintain and restore the wholesomeness of water. It gives powers to water boards to set standards and regulations for prevention and control of pollution.

Besides statutory frameworks, a number of common law principles linking access to water and rights over land are still prevailing in India. These include separate rules for surface and groundwater. Common law standards concerning groundwater have subsisted longer. The basic principle was that access to and use of groundwater is a right of the landowner. In other words, it is one of the rights that landowners enjoy over their possessions. The inappropriateness of this legal principle has been rapidly challenged during the second half of the 20th century with new technological options permitting individual owners to appropriate not only water under their land but also the groundwater found under neighbours' lands. Further, the rapid lowering of water table in most regions of the country has called in question legal principles giving unrestricted rights to landowners over groundwater. Similarly, the growth of concerns over the availability of drinking water in more regions has led to the introduction of social concerns in groundwater regulation. As a result of the rapid expansion of groundwater use, the central government has tried since the 1970s to persuade states to adopt groundwater legislation.

It is only over the past decade that some states have eventually adopted groundwater acts. The legal framework concerning groundwater is still in rapid evolution. It is likely that common law principles will be increasingly challenged despite the fact that the Plachimada high court decision seems to uphold land owners rights to a large extent like. Further, groundwater is increasingly likely to be linked to surface water in the context of the setting up of water regulatory authorities that are called upon to manage surface and groundwater. With regard to environmental impact assessment, the Environmental Impact Assessment Notification provides a framework for assessing the environmental impacts of planned big hydropower and irrigation projects. In addition to all the laws, rules and regulation that make up water law, there is a substantial body of additional rules and regulations at the local level. These include the multiplicity of written or unwritten arrangements that regulate access to and use of water for domestic purposes or irrigation. An array of different rules govern, for instance, access to existing sources of drinking water. They run in many cases along caste lines even though other rules of access also exist. With regard to irrigation water, all human structures such as tanks and check dams include a system of allocation. Rules of access and control have often evolved over long periods of time but are often unwritten or not formally recognised in the legal system.

As a result, they often run in parallel to 'formal' water rules and regulations. Another consequence of the lack of visibility of local level arrangements is that they can easily be displaced or extinguished by new laws that may fail to even acknowledge their existence. The general picture, which emerges is that of a multiplicity of principles and rules, a multiplicity of instruments and the lack of an overall framework. While certain principles have remained relatively constant until recently like the assertion of the state's right to use surface waters in the public interest, there have been a number of changes over time in the basic structure of water law, from the recognition of a human right to water to the introduction of the public trust doctrine.

(Source: https://www.legalservicesindia.com/article/1865/Management-of-Water-and-Water-Laws-In-India)

2.1.1.7. Murray-Darling Basin (Australia)

Water rights are established under state legislation, as water ownership currently vests with state authorities through the Constitution (see for example Queensland Parliament, 2000). The federal government has no powers over water rights or management generally, but in the MDB a joint-management agreement exists to vest responsibilities for Basin management and planning across the four states (i.e. Queensland, New South Wales, Victoria and South Australia), one territory (the Australian Capital Territory), and the commonwealth federal government. In total, approximately19,300GL of water rights have been created, particularly in New South Wales (NSW) and Victoria (Vic), where most of the water storage and delivery points are also located—especially in southern regions along the Murray (border between NSW and Vic) and Murrumbidgee Rivers (also spans NSW and Vic regions). Given the estimated 8,000GL annual average inflows to river systems across the Basin these rights represent a significant over-allocation of rights that could never be fully met in anything but a catastrophic flood year. Requirements to reduce total rights have been repeatedly ignored, although reallocation of water rights though the environmental recovery program has at least created resources for ecological targets and management (MDBA, 2020). Water rights are generally defined as high security offering supply in 95% of years, and general/low security where supply may only be present in around 33% of years. Other rights such as supplementary and drainage rights provide water in opportunistic periods (e.g. high flooding or wet years). State governments regulate and monitor water rights across the MDB, as well as their trade and access—but in conjunction with the MDBA who operate and coordinate major water storage and delivery operations.

2.1.1.8. Orontes River Basin (Lebanon)

In Lebanon, the Ministry of Energy and Water is responsible for managing public water resources. The Water Law No. 77 of 2018 addresses water-related services, including drinking water management, sewage management, and irrigation. The law also establishes irrigation associations to facilitate irrigation usage, implement sustainable irrigation projects, improve techniques, manage distribution networks, and enforce regulations on water usage. The management of irrigation water is the responsibility of public investment institutions and the National Authority of the Litani River. The Ministry of Energy and Water, in collaboration with public water investment institutions, develops the General Water Master Plan for water management, including (i) water needs in key sectors as human consumption, agriculture, livestock, industries and similar activities, tourism and recreational activities; (ii) state of water infrastructure, sewage systems and sea water desalination; (iii) quantities of conventional and non-conventional water, surface water, underground and springs water; and (iv) objectives of sustainable water management. The National Water Sector Strategy approved in 2012 plans to adopt demand-based policies such as metering and volumetric charging, but none of those policies has been implemented. In the 2020 NWSS, the MoEW recommended that the maximum allowable withdrawal should not exceed 500 MCM/year for all of Lebanon.

2.1.2. How does the water allocation system adapt to droughts and water scarcity?

Describe adaptation mechanisms in place to curb down water use during droughts and in contexts of scarcity (supply cannot meet demand on a normal year). Identify key barriers and challenges hampering adaptation to droughts and scarcity.

2.1.2.1. Júcar River Basin (Spain)

Droughts: The Drought Management Plans (DMPs) are regulatory instruments that establish priorities among the different water uses and define more stringent constraints to access to publicly provided water during droughts, especially for non-priority uses such as agriculture. DMPs are inspired in the drought contingency plans implemented in the US since the 80′s and thus follow similar rules (NDMC, 2018). DMPs define the precise thresholds of possible drought situations and set the water constraints that will come into force in each of these cases, with the aim of guaranteeing priority uses. The drought thresholds are obtained from the historical assessment of water supply, while the extent of the water constraints varies from one basin to other and depends largely on the ratio between water demand and water supply, being more restrictive in the more exploited basins such as the Júcar and focusing on agricultural uses (the water use with the lowest priority). Water constraints can be quantitative (reducing water use by a predetermined %) or qualitative (suggestions on how to proceed). It should be noted that DMPs are not legally binding, just an orientation to decision makers, who may decide or not in the context of Drought Commissions whether to enforce the restrictions, or revise them (JRBA, 2005).

Scarcity. Scarcity is mainly managed by the River Basin Management Plans (RBMP). RBMPs are a requirement of the Water Framework Directive (OJ, 2000) and a means of achieving the good ecological status (including good quantitative status) of surface freshwaters (including lakes, streams and rivers), groundwater, ecosystems such as some wetlands that depend on groundwater, estuaries and coastal waters out to one nautical mile. The RBMP sets a programme of measures to achieve this goal, which may also include the revision of water allocations affecting the quantitative status as per the 2001 Water Act.

2.1.2.2. Nitra River Basin (Slovakia)

The water distribution companies, according to the Act No. 442/2002 Coll., have the right to put a temporary ban on using the water distributed by the public water supply in case of water scarcity for other uses than necessary human drinking and sanitary needs, such as irrigation of lawns or filling up pools.

In the long term, groundwater abstractions in the Slovak Republic have decreased. This was mainly due to changes in the economy and due to water price regulation in the period of 1991-2014. Since 2015, the groundwater abstraction has stabilized. Abstractions above 10.0 $l.s^{-1}$ are considered significant. In 2017, a total of 10,607.31 $l.s^{-1}$ of groundwater (including geothermal water) were used and abstracted by consumers subject to the reporting obligation, representing a decrease of 1.04% compared to 2012.

The meteorological, hydrological, and soil drought are monitored by SHMÚ in Slovakia (https://www.shmu.sk/sk/?page=2166). The hydrological drought is monitored in both surface and groundwater (for more details on methodologies see chapter 9.1 of the RBMP and the SHMI website. In addition to the monitoring of "drought" (as a state of natural water availability), "water scarcity", as a water management concept relating to human needs, is mainly addressed by the Action Plan for dealing with the consequences of drought and water scarcity "H_2ODNOTA je voda" (2018) and Water Policy Concept 2030 (see below).

2.1.2.3. Reno River Basin (Italy)

Droughts: During intense droughts (State of Emergency) where environmental flows are at risk, a Commissioner Delegate is appointed by the central government who may issue extraordinary water allocation rules. The contemporary regulatory framework encourages voluntary agreements among users before binding restrictions are issued. If no arrangements are reached that ensure good ecological status, unilateral restrictions can be imposed (Pérez-Blanco et al., 2017; PRBA, 2003). According to the Environmental Code, license holders are entitled to abstract a specified quantity of water from a particular source and for a specific purpose. The license award is conditional to conformity with minimum environmental flows. If the latter are not guaranteed, the regulator may impose revision or revocation of a license. Temporary limitations may be enacted during prolonged periods of droughts.
Scarcity: Scarcity is mainly addressed by the River Basin Management Plans (RBMP) and Water Balance Plans, but there are also local planning and programming tools. RBMPs are a requirement of the Water Framework Directive (OJ, 2000) and a means of achieving the good ecological status (including good quantitative status) of surface freshwaters (including lakes, streams and rivers), groundwater, ecosystems (such as some wetlands that depend on groundwater), estuaries and coastal waters out to one nautical mile. An instrument of these Plans is the Permanent Basin Observatory of water uses, which monitors the evolution of the scarcity situation and identifies mitigation measures before the possible emergency phase.

2.1.2.4. Tympaki River Basin (Greece)

The impacts and restrictions of periods of drought and water scarcity on water availability and water use are addressed through a series of measures, reflected in the respective Management Plans that have been developed. Specific measures for drought are included in the WFD River Basin Management Plan of Crete, which is currently in the second revision phase (http://wfdver.ypeka.gr/el/project/approved-el13-12-1revision-measures-gr/), e.g. Implementation of a Strategic Plan to Address Drought and Water Scarcity events (measure M13B0308) including water saving measures, awareness rising, etc.)
At the same time the Decentralized Administration of Crete has developed an operational plan for responding and management drought and water scarcity situations in Crete, i.e. "Action Plan to combat Drought and Water Scarcity in Crete (April, 2021)". Moreover, the Region of Crete has incorporated six (6) actions and seventeen (17) measures for the adaptation of water resources to climate change in the sector policy planning for the Region of Crete "Regional Plan for Adaptation to Climate change in Crete (PESPKA), (December 2021)".

On an operational level, the Region of Crete monitors water levels in the Faneromeni reservoir, where a maximum withdrawal coefficient is defined per year. This coefficient is applied and withdrawals are subject to an upper limit every year.

The Local Land Reclamation Organisation (TOEV) has specific regulations for a dry hydrological year:

- TOEV informs all the farmers, before the summer period, that the running year is considered as "Dry year" and then TOEV applies the relative regulations.
- TOEV will apply the specified minimum irrigation dose to crops, e.g. for olives trees in a normal year is 250 m3/ha whereas in a dry year is 150 m3/ha
- TOEV will apply special tariffs (penalty) to over-consuming farmers, e.g. the water cost/m3 is 0.25€ for the dose of olive trees, whereas the over-consuming water cost is 0.5€ in dry years

2.1.2.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

There are separated protocols by country:

Peru: The Basin Water Resources Council evaluates the rights according to the needs of the concurrent users in the basin. This Council recommends to the AAA whether to approve a water use license or not. The rights are granted based on a water balance analysis submitted by the users. This analysis includes climate variability, so that critical scarcity scenarios are evaluated. A certain flow or volume is assigned on an annual basis. Water licenses allocate a total volume of water that each user can use every year, this is updated yearly. In basins where the water source has been declared depleted (use has reached the maximum allowable), no more licenses are granted. Permits are granted on a temporary basis when there are water surpluses. Authorizations are approved to carry out works or to modify some infrastructure and are of a temporary nature. (Huanacuni & Cambillo, 2023). There are no specific protocols beyond the yearly evaluation in the case of droughts or water scarcity situation. One characteristic of the allocation in the case of the pacific region of the system manage by the Peruvian institutions is that due to natural water scarcity of the region they allocate carefully each water source at the level of create specific projects to monitor this allocation and project future scenarios to prepare the region for the ongoing increase of water demand [one example is Special Project Tacna (PET)].

Bolivia: In the national context, the integrated management is a tool of adaptation which involves the participation of entities at the national and subnational levels, and is articulated, from the ministry of environment and water [MMAyA], responsible for designing, establishing, applying and supervising national and sectoral environmental policies; as well as water, there is the National Plan of Basins [PNC] and inter-institutional platforms, such as the Platform of the Master Plan of the Katari River Basin from the Titicaca Lake system in the upper site and the Inter-institutional Platform of the Lake Poopó Basin in the downstream site, allowing coordination of institutions with civil society in watershed management. In terms of drinking water and basic sanitation, the MMAyA is involved, in charge of ensuring the sustainable use of services, as well as regulating, preventing and controlling water contamination for human consumption, and dependencies at the national, departmental and local level. The entity created to monitor and regulate is called Water and Sanitation Authority [AAPS], responsible for protecting and guaranteeing the use of water for human consumption, which implies the control, supervision, and regulation of the local companies in charge of water services [municipal level] The latter must carry out their respective Strategic Plan for the Sustainability of Water Sources and include the treatment of wastewater8. Recently, and due to the increase in the frequency of droughts, MMAyA has developed special plans of droughts for specific regions considering mainly big regional capital cities which eventually may be included in PNC plans but currently this is not the case.

2.1.2.6. Mahanadi River Basin (India)

From 1900 to 2002, droughts in India resulted in 2 750 430 deaths and affected some 900 million people, apart from huge financial losses. It is the creeping effect of drought over long periods and its severity that sensitized the Government of India to treat the problem from several angles—scientific, technological, economic, social and environmental. Some of the initiatives taken for drought management by the Government are:

- Enhancement of the capabilities of long-range forecasts to climate modelling and weather forecasting;

- In 1989, the National Centre for Medium Range Weather Forecasting started to forecast weather on a medium-term basis (3-10 days in advance);
- Monitoring of storage position of reservoirs: 76 important reservoirs of the country having a total live storage capacity of 131.22 billion m3 are being monitored. A further 49 have also been identified for inclusion in the monitoring system, which will increase storage capacity of the monitored reservoirs to 156.69 billion m3, i.e. about 74 per cent of the total capacity of 213 billion m3 created so far;
- Efforts are under way to improve the efficiency of the irrigation system;
- The National Agricultural Drought Assessment and Monitoring System became operational in 1989;
- The National Centre for Disaster Management was set up in 1995 to undertake human-resource development, research, building a database and providing information services and documentation on disaster management;
- Many programmes to prevent/ mitigate drought in the long term;
- Supporting research to provide solutions to drought-related problems;
- Setting-up of a National Data Bank under the All India Co-ordinated Project on Agrometeorology at the Crop Research Institute for Dry Land Agriculture, Hyderabad;
- Setting-up of a National Disaster Management Authority.

The new Drought Risk Management Programme under formulation aims to build on the previous Programme's experience to reduce the vulnerabilities of communities to drought through community-based approaches and appropriate risk management and better decision-support systems at state and district levels. (Das et al, 2007)

For water scarcity problems, water conservation initiatives are taken up by the Central Government on continuous basis and are covered under various schemes and programmes such as Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS), Atal Bhujal Yojana, Pradhan Mantri Sinchayee Yojana (PMKSY), Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Unified Building Bye Laws (UBBL) of Delhi, 2016, Model Building Bye Laws (MBBL), 2016, Urban and Regional Development Plan Formulation and Implementation (URDPFI) Guidelines, 2014 etc.

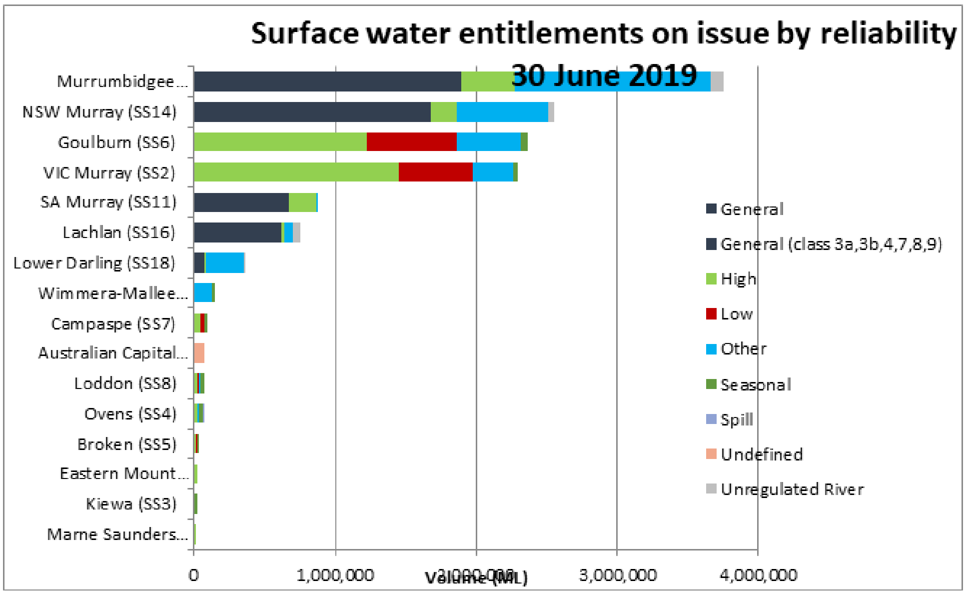
In order to boost water conservation and rain water harvesting in the country, Ministry of Jal Shakti has taken up a nationwide campaign "Jal Shakti Abhiyan - Catch the Rain" (JSA:CTR) with the theme "Catch the rain, where it falls, when it falls" for creating appropriate rainwater harvesting structures in urban and rural areas of all the districts in the country, with people's active participation, during the pre-monsoon and monsoon periods.

States/ UTs have been advised to enable Rural Local Bodies/Panchayats to utilize 15th Finance Commissions grants to take up rooftop rain water harvesting in Government buildings like the Panchayat Bhawans, Anganwadis, Primary Health Centres etc. Master Plan for Artificial Recharge to Groundwater- 2020 has been prepared which envisages construction of about 1.42 crore rain water harvesting and artificial recharge structures in the country. Government organizes workshops, seminars/webinars, awards etc. and encourage people to become active participants for water conservation and rainwater harvesting. Central Ground Water Authority (CGWA) has advised all States/UTs to take measures to promote/adopt artificial recharge to ground water /rain water harvesting. National Water Policy (2012) advocates water conservation and rainwater harvesting.

Traditional methods of water conservation and rain water harvesting in the country varies from area to area depending upon the topography, climatic conditions, soil structure, etc.
(Source: https://pib.gov.in/PressReleasePage.)

2.1.2.7. Murray-Darling Basin (Australia)

Mostly by trade in recent decades. As progress toward full agreement on state water sharing plans remains slow (see above) the main adjustment mechanism is water trade. Trade occurs mostly across the southern states where storages and connected delivery systems provide increased trade opportunities over northern parts of the Basin (i.e. in the north there are limited storage dams, lower connectivity, and less irrigation supply networks). Trade will be predicated by allocation changes too, where each state has the capacity to reduce allocations to water users in line with their rights—especially general/low right holders. High security right holders retain access in 95% of years, which comes at the expense of general/low security right holders supplied by MDB dams. Of the roughly 19,300GL of MDB rights the proportion across each class is shown below. Note that for surface water, high security rights are more prevalent in Vic—and general rights more prevalent in NSW—and that total MDB dam storage capacity will only meet about 2 years' of high security demand at present, when starting from full.



Source: (BoM, 2020)

In drought or low supply conditions state's water management teams reduce allocation levels across the rights under calculators based on current storage levels, expected demand, predicted annual storage inflows, evaporation losses etc. Examples of these variations can be seen below, where red allocations denote 0% allocations to some rights in dry years for the 20 southern water right zones in the MDB:

Note also that as an example, South Australia (SA) has a limited irrigation area, and little to no large-scale storages, but large perennial cropping (e.g. wine and almonds) dependent on high security—and supply from storages in the other states. The period shown above includes one of the worst droughts in living memory (i.e. the Millennium Drought 2001-2010) and more recent returns to wetter years (i.e. 2020). The figure shows the variability year-on-year and how allocation shifts both encourage and signa the need to adapt annually. Allocations are flagged every 2 weeks once the water year opens i.e. Apr/May annually), and are not adjusted downward at any time after being announced to ensure some certainty for application planning and delivery.

2.1.2.8. Orontes River Basin (Lebanon)

In Lebanon, water management faces significant challenges due to the presence of numerous institutions, fragmented decision-making processes, a lack of responsibility, and ineffective political parties. The country's water resources are not effectively managed by any entity despite the involvement of multiple actors. The existing legal framework for the water sector in Lebanon is disorganized and lack structure, leading to mismanagement and overlapping responsibilities. In 2010, the government of Lebanon adopted its first water policy strategy: the National Water Sector Strategy (NWSS) to ensure water supply, irrigation, and sanitation services in the country on continuous basis. The updated NWSS action plan (2020) includes a drought mitigation plan that is part of an integrated hydrological information system implementation strategy (IHIS). The IHIS aims to allow for better planning of infrastructure and adequate water allocation among economic sectors.

2.1.3. How does the water allocation system adapt to climate change?

Describe adaptation mechanisms in place to curb down water use, so as to adapt water use to available resources under climate change. Identify key barriers and challenges adaptation to climate change.

2.1.3.1. Júcar River Basin (Spain)

Water rights are defined in absolute terms instead of as shares over available resources. Thus, a reduction in water availability will not result in a reduction in water allocation. Discretionary revisions of such water allocation rules and rights are nonetheless plausible, provided they affect third parties or the good ecological status of water bodies, as per the 2001 Water Act.

2.1.3.2. Nitra River Basin (Slovakia)

Water permits are issued for ten years, which gives a degree of flexibility to react to a decrease in water resources caused by climate change. The water authority is bound to maintain the minimum water flow or minimum groundwater level respectively, which should ensure all the ecosystem services of the water resources. The Water Policy Concept 2030 (see below) is aiming to define so called ecological water flow levels. These will be legally bound minimum flows, which will ensure and account for the needs of, both, humans and aquatic organisms.

2.1.3.3. Reno River Basin (Italy)

The licenses are specified in absolute terms and are not transferable. Moreover, the temporal horizons for which the licenses are issued do not take into account the changing availability of water resources in the medium and long-term, as a result of climate change. Nor do they consider changes in the demand for water driven by population growth and economic development. Since human-induced climate change will likely result in a lower average annual water availability and a greater intra- and inter-annual variability (Vezzoli et al., 2015), the National Climate Adaptation Strategy for the Po River Basin District (PRBD) has suggested revising the WAL regimes (CMCC, 2017).

2.1.3.4. Tympaki River Basin (Greece)

The most recent Regional Plan for Adaptation to Climate change in Crete (PESPKA) (December 2021) simulated climate change conditions in Crete using EURO-CORDEX RCMs (CCLM4-8-17, HIRHAM5, RAMCO22, RCA4) downscaled for Crete, for Scenarios RCP 4.5, RCP 8.5. The reference (baseline) period was 1980-2022, while estimates of changes in meteorological parameters were simulated for the future periods 2021-2040, 2041-2006 and 2081-2100. Parameters relevant to the water resources have been simulated such as increase in mean temperature, increase in max temperature, reduction in mean annual rainfall, increase in drought duration (consecutive days with rainfall < 1mm), etc. Furthermore, the vulnerability of the water resources reserves (water availability and flood risk) have been defined for the aforementioned three future periods for the entire Crete (per municipality), as well as the vulnerabilities of the related economic sectors (e.g. agriculture, energy supply) and basic infrastructure works. The related expected impacts have also been defined, along with the probability of occurrence, the time span of occurrence (short-term, medium-term, long-term), and the adaptation/mitigation potential. A series of mitigation and adaptation measures have been accordingly proposed (including measures for the operational monitoring of water reserves, updating/adjusting max allowed abstraction rates and optimizing water allocation, promoting conservation and wastewater reuse, etc.), also in alignment with the measures included in the Crete WFD RBMP. These measures are suggested to be further elaborated and refined for each specific area/prefecture of Crete.

2.1.3.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

In general, no plans of regulations related to water allocation for the system currently ask to include climate change evaluation, users are not being asked to include an analysis that considers climate change to determine future critical water supply conditions. But some studies do present analyses including climate change (Huanacuni & Cambillo, 2023), but considering the complete region [TDPS], this under the elaboration and update of the integrated Master Plan of the system9, which may stablish the rules for water allocation in the complete region but not at the basin level.

2.1.3.6. Mahanadi River Basin (India)

Climate change is just one of several factors influencing the hydrological system and water resources. Current policies affecting water use, management, and development are often contradictory, inefficient, or unresponsive to changing conditions. Past efforts have focused on minimizing the risks of natural variability. Tools for reducing these risks have traditionally included supply–side options such as new dams, reservoirs, and improving efficiency. This is largely independent of the issue of climate change, which will have important implications for the ultimate severity of future water stresses. Recommendations and observations on how to cope with the climate change issue in terms of future water resources in India are as follows:

(i) Prudent planning requires that a strong national climate and water monitoring and research programme should be developed, that decisions about future water planning and management be flexible, and that expensive and irreversible actions be avoided in climate–sensitive areas;

(ii) Better methods of planning under climate uncertainty should be developed and applied;

(iii) Decision makers at all levels should reevaluate technical and economic approaches for managing water resources in view of potential climate changes. The government should ask all states managing national water systems to begin assessing both climate impacts and the effectiveness of different operation and management options;

(iv) Improvements in the efficiency of end uses and the management of water demands must now be considered major tools for meeting future water needs, particularly in water–scarce regions. Water demand management and institutional adaptation are the primary components for increasing system flexibility to meet uncertainties of climate change;

(v) Water managers should begin a systematic re–examination of engineering designs, operating rules, contingency plans, and water allocation policies under a wider range of climate conditions and extremes than have been used traditionally. For example, the standard engineering practice of designing for the worst case in the historical observational record may no longer be adequate;

(vi) Cooperation between water agencies and leading scientific organizations can facilitate the exchange of information on the state–of–the–art thinking about climate change and impacts on water resources;

(vii) Timely flows of information among the climate change scientists and the water–management community are valuable. Such lines of communication need to be developed;

(viii) Traditional and alternative forms of water supply can play a role in addressing changes in both demands and supplies caused by climate changes and variability. Options to be considered include waste water reclamation and reuse, rainwater harvesting and even limited desalination where less costly alternatives are not available. None of these alternatives, however, is likely to alter the trend toward higher water demand in the future; and

(ix) Prices and markets are increasingly important for balancing supply and demand. Because new construction and projects can be expensive, environmentally damaging, and politically controversial, the proper application of economics and water management can provide incentives to use less and produce more. Among the new tools that need to be explored are water banking and conjunctive use of groundwater. (Lal, 2000)

2.1.3.7. Murray-Darling Basin (Australia)

In the main, for the MDB it is supposed to be through the Plan. There are four levers or policy instruments aimed at promoting and assisting adaptation to climate change:

1. First, Best Available Science (Sect. 4.03(g)(iii) and Sect. 6.06(3)) must be used to regularly review and update the Plan with any emerging knowledge about climate change (Neave et al., 2015). At its drafting, the Plan was arguably based on the best available science (Kneebone and Wilson, 2017) though whether that remains the case is questioned by some (see below).
2. Second, immediate action to address environmental impacts and ensure ecological resilience to future climate impacts (Sect. 5.03(1)(c)) is to be achieved by Recovering Additional Water for ecological use.
3. Third, water recovery combined with refinements to existing Water Sharing Plans (Sect. 10.51(3)) is expected to buffer systems from the stressors of a drying climate (MDBA, 2019).

4. Finally, Water Markets are expected to provide users with capacity to adapt to climate change impacts in future (Sect. 5.07(2)(c)(ii)).

The effectiveness of these levers has been questioned by analysts—for example, Grafton *et al.* (2020) argue the Plan in no way takes climate change into adequate account while Alexandra (2020) concludes the Plan does not reflect current scientific consensus on climate change, makes no allowances for declining water availability, and finds that any adoption of explicit climate adaptation or mitigation measures will be problematic as a consequence. However, these claims are not really tested in any empirical way. Water trade remains one of the best adaptation tools available to users at present (for example, see work by Wittwer and Griffith, 2011).

2.1.3.8. Orontes River Basin (Lebanon)

Lebanon's economic policies are outdated and fail to account for future changes. The country currently lacks comprehensive water policies, but there are initiatives undertaken by national and international organizations to address water security. The Ministry of Energy and Water has established the Water Law to organize the water sector, which includes provisions for public planning projects related to the allocation and distribution of potable and irrigation water at the national level. The law also mandates the development and continuous updating of a master plan for water and wastewater, which is to be submitted to the Cabinet by the responsible Minister. These actions aim to address water management and ensure sustainable water resources in Lebanon.

2.1.4. Are there public registers with thresholds and standards fixed that are widely accepted?

Describe whether there is a public register, and the standards (e.g., unit(s) of measure used in the register, such as m3, capacity of the pipe, other) and thresholds for water use (e.g., daily amounts, seasonal monthly, other) used. Indicate the presence of dozers / sleeping licenses. List any potential challenges/barriers to have a public register.

2.1.4.1. Júcar River Basin (Spain)

- There is a public register of water rights in Spain, which is managed by the River Basin Authorities or the Regional Authorities depending on the type and location of the water resource. The public register contains information on the holders, volumes, locations, durations and conditions of the water rights granted by concessions or authorizations.
- The unit of measure used in the public register is cubic meters (m3), which is also the unit used for water tariffs and metering. The public register also includes information on the capacity of the pipe or infrastructure used to abstract or discharge water.
- The thresholds for water use depend on the type and location of the water resource, as well as on the type and purpose of the use. For example, for groundwater resources, there is a general threshold of 7,000 m3/year for domestic use without a concession or authorization, but this threshold can vary depending on the region and the status of the aquifer. For surface water resources, there is no general threshold for domestic use without a concession or authorization, but some regions have established specific thresholds depending on the availability and quality of the water
- The presence of dozers / sleeping licenses is not explicitly regulated by law, but there are some provisions that aim to prevent or discourage them. For example, the Water Law establishes that water rights can be revoked or modified by the competent authority if there is a change in the

use or location of the water resource, if there is a breach of the conditions of the concession or authorization, or if there is a public interest reason.

- Some of the potential challenges/barriers to have a public register are: 1) the lack of coordination and harmonization among different administrations and regions that manage water rights; 2) the existence of illegal or unregulated water abstractions that are not registered or controlled; 3) the insufficient updating and verification of the information contained in the public register; 4) the low level of public access and transparency of the public register

2.1.4.2. Nitra River Basin (Slovakia)

There is no public register or standards available.

2.1.4.3. Reno River Basin (Italy)

No public and centralized census is available. The Legge Galli N.36, 1994 and the Environmental Code oblige water right owners to declare their existence and characteristics in order to make an overall census possible, although this objective has so far failed to be fully attained in the Reno Basin and the Po River Basin District. There are reports of a significant amount of sleeping licenses currently non-used, which when aggregated to existing licenses could exceed available supply (Santato et al., 2016). In general, for each water usage, monitoring and measurement processes are provided. On the other hand, a national data system named SIGRIAN is available exclusively for monthly and regional irrigation withdrawals.

The SIGRIAN database stands for Informative National System for Management of Water Resources in Agriculture and it has been developed and managed by CREA-PB (Council for the research in agriculture and the analysis of agricultural economy, Policy and Bioeconomy research center). This database is a reference for all the administrations and competent institutions concerning water for agriculture, relatively to water volumes for irrigation, on the basis of the D.M. MASAF 31/07/2015.

The system gathers technical-economic information regarding water management in the agricultural field, described by territorial institutions and alphanumeric data which is contained in a Relational Database Management System (RDBMS) open source. This information is related to: structure of collective irrigation, measured and estimated data concerning automatic supply irrigation which is aggregated on a municipal basis, the execution of the PSRN (National Plan for Rural Development) and finally the application of rules by MASE (Ministry of Environment and Energy Security), which incorporates the methods for internalizing the environmental cost and water source for various purposes, including agricultural use (D.M. 24/02/2015, n. 39).

Lastly, SIGRIAN represents the system by which the institutions in charge, coordinated by regions and public administrations (P.A.s), are required to transmit the values of irrigation volume withdrawals with defined time intervals.

2.1.4.4. Tympaki River Basin (Greece)

Within the framework of the River Basin Management Plan for Crete (Government Gazette 570/B/08-04-2015) and in implementation of the Joint Ministerial Decision 146896/2014 (Government Gazette 2878/B/27-10-2014) and the decision of the Secretary General of the Decentralized Administration of Crete 5656/2015 (Government Gazette 2055/B/18-09-2019), the Water Directorate of the Decentralized Administration of Crete (WDC) grants water use permits to interested water users.

These beneficiaries can be either public stakeholders (Municipal Water Supply and Sewerage Companies - DEYA, Local Land Reclamation Organisation -TOEV, Municipalities) or private individuals. Each license specifies the annual quantity that can be used by the user. The quantities of water are determined according to use and are subject to a maximum limit. The usage limits are detailed in the decision of the Secretary General of the Decentralized Administration of Crete 5656/2015 (Government Gazette 2055/B/18-09-2019). At the same time, there is a public archive of water use licenses, which is available on the website of the Decentralized Administration of Crete (https://geoportal.apdkritis.gov.gr/gis/apps/webappviewer/index.html?id=e599cf564c1b4510ad079dac10467d2d).

Within the WFD RBMPs there is also a basic measure foreseen for the control of surface and groundwater abstractions and surface water storage which requires the annual electronic recording of surface water and groundwater abstractions (M13B0502). More specifically, this measure specifies that the annual electronic registration is mandatory for all withdrawals over 3,650 m^3 per year. This data will give an overall picture of the abstractions. The VAT number of the beneficiary/owner of the water use permit will be used. Each user will submit the volume of water abstracted electronically, within the first ten days of November each year. For users who already have a non-resettable water meter, the meter reading, date and meter serial number will be recorded. For boreholes connected to electric power supply, the electrical supply number will also be recorded. In the case of water abstraction intakes that do not have a water meter, the maximum annual permitted withdrawal will be recorded, according to the license, as an incentive to install water meters in the existing water intakes.

At the local level (in Tympaki basin) the Region of Crete defines a maximum annual withdrawal rate (coefficient) from the Faneromeni reservoir which is used for irrigation purposes. This reservoir provides irrigation water to other areas as well, besides Tympaki, so these coefficients are defined for each supplied area based on an exisiting water allocation scheme. The Local Land Reclamation Organization "TOEB of A' Zone of Messara" also maintains a complete record of irrigation water consumption and usage, which is not publicly accessible though. The overall water usage report is presented in detail every year at the annual general assembly of the TOEV members. The competent Municipal Water Supply and Sewerage Company "DEYA Faistou" also maintains a complete record of domestic water supply and usage, which is not publicly accessible though. Each user received a water bill, where the volume that has consumed is registered according to its water meter measurements.

At a national level, the Special Secretariat for Water (SGW) of the Ministry of Environment and Energy is the competent service for monitoring the qualitative and quantitative status of surface and groundwater, in cooperation with the Water Directorates of the Decentralized Administration, maintaining the respective measurement records.

2.1.4.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

Peru: There is an updated census of users in the Pacific and the Maure regions. The water allocated per user is measured in volume (m3) accumulated in the year. (Huanacuni & Cambillo, 2023). The allocation is accepted in the case of Pacific region, however there are not supplied demands which require formulation of projects and actions to improve the water deficit. In the case of Maure region in the upper site of the system despite the yearly allocation of water there are some disagreements related to the water transfers to the Pacific region by the local communities.

Bolivia: There is no registers about water allocation to the users beyond the technical specification of irrigation systems. This specification may have data about irrigated area, type of water source and in some cases hydraulic constraints related to the diversion infrastructure. From the point of view of water consumption by the communities and cities, there a yearly reports of water use, but not in the case of the small communities. In the case of studies MMAyA in Bolivia estimated the water demands in the regional system TDPS, for all sectors but considering secondary factors such as population, number of industrial and mining activity, number of camelid cattle based on national census from 2012, and agricultural census from 201310. This scenario shows that the current water users do not acknowledge thresholds or standards to fixed water consumption in its activities beyond the reports and data described previously, which may show a risk from the regulation point of view.

2.1.4.6. Murray-Darling Basin (Australia)

Yes. Each state has a public water register that is accessible and transparent (see for example the Victorian Registry here), together with a national registry of water rights, uses and accounting through the Bureau of Meteorology website. The data is largely supported and agreed to by users and analysts, offering a highly valuable and critical reference site for MDB water resources. Water information and updates are also available from local irrigation infrastructure operator sites (e.g. Goulburn Murray Water website in Vic) which also provides updates fees and charges, allocation updates, delivery expectations and delays, and trade restrictions if any. These have become well-trusted sites for MDB water users.

2.1.4.7. Orontes River Basin (Lebanon)

There is no official monitoring of irrigation water in the Orontes River Basin. However for domestic use the units of measurements used in the public register are m^3.

2.1.5. Are there reported infringements of water rights (water theft, other)?

Describe whether there are infringements of the water allocation system (general principles, illegal abstractions, other).

2.1.5.1. Júcar River Basin (Spain)

In Spain, the incidence of water theft has nearly doubled from 510,000 illegal wells extracting 3570 million m3/year in 2006 to an estimated 1,000,000 illegal wells extracting in excess of 7,000 million m3/year in 2020—that is, more than a half (53%) of the total volume of groundwater extractions is currently unauthorized (Schmidt et al., 2020). The problem of illegal wells is compounded by an unknown volume of unauthorized extractions by licensed users in excess of their formal allocations (i.e. over-extractions) (IMPEL, 2017). Climate change is expected to amplify the incidence and impact of unauthorized extractions due to reduced water supply and increased competition for the resource (Felbab-Brown, 2017). Against this backdrop, public water authorities have pledged commitment to curb water theft, albeit with limited success. Only 7,557 cases of unauthorized extractions have been prosecuted over the last decade in Spain, less than 0.8% of those estimated, a disappointing performance that has been attributed to poor detection and enforcement mechanisms (Loch et al., 2020). River basin authorities in Spain have estimated the damage arising from this reduced sample of prosecuted cases at EUR 3 million per year (Greenpeace, 2020), suggesting that the economic cost of water theft nation-wide may be one or two orders of magnitude higher. However, the penalties applied to offenders are typically set below reported damages (partly due to poor detection mechanisms providing insufficient/incomplete proof on the extent of the infringement) and below the expected returns from unauthorized extractions (of several thousands of EUR/ha for high value-added crops such as vegetables), which increases the incentives to steal (Loch et al., 2020).

Cost recovery is also insufficient to recover financial costs, let alone resource or environmental costs.
It has been argued that some infrastructures (such as the Tagus-Segura transfer, see e.g., https://www.acuademia.com/2023/04/el-trasvase-desde-el-tajo-es-para-regadio-aunque-se-venda-que-es-para-abastecimiento/) are needed to meet urban demand in a context of growing scarcity in water scarce basins of the south and east. River basin plans even allocate part of water from water transfers and other non-conventional water sources to urban use, which suggests that without these resources, urban demand would not be met. This is nonetheless a strategy to justify such water works: since water availability largely exceeds urban demand in these basins, and urban water demand is a high priority use, not meeting urban demand would be an infringement of the law. Therefore, if those water works would not be available, the result would be less water available for lower priority uses—that is, irrigation.

2.1.5.2. Nitra River Basin (Slovakia)

SVP (the water manager appointed by the Ministry of Environment) do not have any reported information regarding water infringement or theft. The Water Act No. 364/2004 recognizes water patrol, which can be established by the state water authority on behalf of the water manager, owner of a waterwork, towns. Water patrol´s duty is to control compliance to the Water Act and report to the water authority in case the water user is not following the law. In such case, water patrol reports to the water authority (usually the district authority) who process the case. The water authority may then decide to terminate the water permit in case one was granted to the user who broke the rules.

2.1.5.3. Reno River Basin (Italy)

Limited data is available for the Reno living lab. The DIANA project estimated about 1.5 million unlicensed wells in Italy, mostly in the south. In "eight regions (Abruzzo, Molise, Puglia, Campania, Basilicata, Calabria, Sicily and Sardinia), about 830,000 hectares are irrigated legally, while the total irrigated area reaches about 1.6 million hectares". In the Puglia region alone, "it is estimated that there are 300,000 unauthorized wells, which provide for one third of the total irrigated area in that region" (Schmidt et al., 2020).

Cost recovery is also insufficient to recover financial costs, let alone resource or environmental costs, which is non-compliant with the EU WFD.

There are no particular infringements reports overall.

2.1.5.4. Tympaki River Basin (Greece)

Within the framework of its responsibilities, the Water Directorate of the Decentralized Administration of Crete (WDC) and the Department of Water Economy of the Region of Crete carry out inspections for the proper use (according to their terms) of the issued water use licenses. In cases where violations are found, the WDC takes the corresponding administrative actions provided for by Law 3199/2003. When violations are detected, action is taken including shutting down of the abstraction point and recalling the water use license.

2.1.5.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

In the Pacific region [Caplina basin], the Local User Boards oversee verifying if there is any illegal extraction, and the Local Water Administrator Caplina Lucumba is in charge of legal and sanctioning process in case of non-compliance with the license or informal water withdrawals. Approximately 95% of surface water users in the basin are formalized. In groundwater, only 5% of users are formalized. (Huanacuni & Cambillo, 2023).

In the Maure – Mauri region, there are no binational regulation to penalize infringements, beyond the national control in their respective territory, which have same characteristics as we described by pacific region in the case of Peru, but in the case of Bolivia due to level of control [regional and national] there is not enough monitoring process to detect and penalize infringements. Mainly because of water use in the Bolivian site of the Maure – Mauri basin is at level of small and scatter communities the water and considering the vulnerability of sensitive ecosystems such as bofedales, an inventory of this water requirements since social and environmental impact is highly necessary.

In the Desaguadero basin at the downstream part of the system there are big irrigation systems which were privately built with no regulation for the regional or national authority. Because of that, currently, there is a high probability of infringements which in many cases may create damages to water users in downstream areas and critical environmental impact at Poopo and Uru Uru lakes. Under this problem, the national government has been carried out the completion of an inventory of these systems.

2.1.5.6. Mahanadi River Basin (India)

There are no instances of illegal water abstraction reported from the basin. However, allocation of rights to industries, especially thermal power stations, to divert water from Mahanadi River and its tributaries in Chhattisgarh part of the basin had invoked protests from the fishing communities and farmers from that state. Further, the decision of Chhattisgarh government to build more dams and diversion systems had prompted the government of Odisha to approach the Union government (the Ministry of Water Resources, River Development and Ganga Rejuvenation) to adjudicate sharing of water from Mahanadi between Odisha and Chhattisgarh, as they fear that it would deprive them of their due share of water for Hirakud reservoir. The Mahanadi Water Disputes Tribunal was subsequently set up on 12th March 2018 by the Union government.

2.1.5.7. Murray-Darling Basin (Australia)

Yes, although as far as we know they remain small in the relative scale of water use and hidden in jurisdictions where detection, compliance and penalties remain limited (Loch et al., 2020). Limited data and analysis is available given the nature of theft and some irrigators' attitudes to the activity (i.e. a culture of silence prevails). NSW now has the most modern theft assessment and monitoring arrangements in the MDB after a scandal in 2016 (NSW Ombudsman, 2018). Their systems have most recently identified about 400 possible breaches in 2020-21, prosecuting 10 cases (2.5%), any finally prosecuting eight users in total. Penalties remain an issue though, and the issue of water theft was raised as a federal government priority in 2022 , and changes to the MDB Compliance and Enforcement arrangements in 2021 (Australian Parliament, 2021b). See specific cases noted further below in the penalty section of the White Paper (Sect. 2.5.4).

2.1.5.8. Orontes River Basin (Lebanon)

Illegal connections, illegal abstraction of groundwater. For all of Lebanon, the total number of illegal private wells in 2014 was estimated by the MoEW to range between 55,000 and 60,000 wells.

2.1.6. Which enforcement, sanction and penalty systems are in place for addressing illegal abstractions (water theft)?

Describe legal systems in place to act against offenders or resolve disputes on the interpretation of the existing law. Identify key barriers and challenges hampering compliance.

2.1.6.1. Júcar River Basin (Spain)

For theft, disciplinary proceedings are managed by the River Basin Authority and typically include the closure of wells and farms (where land is used illegally), and fines ranging from minor (<EUR 10000) to medium (EUR 10000-50000), grave (EUR 50000-500000) and very grave (EUR 500000-1000000) depending on the quantity of water abstracted and the environmental damage caused (BOE, 2011, 1993); although the difficulty to identify the final user(s) and quantity of water abstracted typically results in considerably lower fines. Disciplinary proceedings are usually appealed by defendants, taking years to be ratified and enforced.

Incentives towards water theft are exacerbated by the uncontrolled granting of agricultural subsidies. Under the Common Agricultural Policy 2007-2013, irrigators can receive subsidies towards the acquisition of machinery and the construction of greenhouses and irrigation networks, which in several cases have been used to develop illegal irrigation schemes and farms (Galdón et al., 2017; WWF, 2017). EU institutions can also act where theft is widespread and fine the country where this is taking place. For example, in January 2019, the EC referred Spain to the ECJ "over a failure to take adequate measures to protect the groundwater bodies that feed the Doñana Wetlands", and the resultant "deterioration of protected habitats in these wetlands" (EC, 2019). Doñana is outside of the Júcar lab but provides an example of the current framework.

Amensties for illegal irrigators and the incorporation of their farms to the irrigable area is common in Spain. Also outside of the Júcar living lab, in 2008 the Spanish government sought to buy back water from legal farms in the Upper Guadiana River Basin with the purpose of restoring the balance in the overabstracted Tablas de Daimiel National Park aquifer (70% of the water reacquisition) and regularizing illegal water users (remaining 30%) (GRBA, 2008). Note that, as mentioned in previous sub-sections, in Spain water is a public good and institutions are entitled to cancel rights to private users where these negatively affect the public domain; although the institutional costs of doing so are high and other solutions such as buyback are often revealed preferred (BOE, 2001). Purchase tenders in the Upper Guadiana invested EUR 66 million to buy 13.3-13.6 million m3 of "paper rights" and only 1-2 million m3 of actual water withdrawals (i.e. 33-66 EUR/m3), which were fully used to regularize illegal farms (Fernández-Lop and Hernández Herrero, 2013). Other (minor) buyback programmes in Spain have been more successful, including temporary acquisitions to legal water users in the Júcar (Garrido et al., 2013). Note also that the legal feasibility of buyback has been challenged by EU institutions, which are committed to the polluter-pays principle and typically react to beneficiary-pays-based schemes such as buyback with lawsuits (see e.g. BOE, 2017). Moreover, the costs of buyback in the highly profitable agriculture of the Júcar is likely to be high (Pérez-Blanco and Gutiérrez-Martín, 2017).

2.1.6.2. Nitra River Basin (Slovakia)

The Water Act No. 364/2004 Coll. defines the sanctions of illegal water abstraction based on the water volume abstracted (m^3). In case of surface water, 1 euro per 1 m^3 but a minimum of 1000 euro is charged. Illegal abstraction of groundwater is charged 2 euro per 1 m^3 but a minimum of 2000 euro is sanctioned. The Water Act defines the maximum sanctions depending on the type of infringement.

2.1.6.3. Reno River Basin (Italy)

Not implemented in case study site. Disciplinary proceedings are managed by the River Basin Authority and typically include the closure of wells and farms (where land is used illegally), and fines.

2.1.6.4. Tympaki River Basin (Greece)

The Water Directorate of the Decentralized Administration of Crete (WDC) and the Department of Water Economy of the Region of Crete (namely the so-called Environmental Quality Control Bodies – KEPE) carry out self-proclaimed inspections and controls or after a named justified complaint, for violations of the provisions of water use licenses or for illegal wells, according to the Joint Ministerial Decision 146896/14. In the case a violation is found, the expenses for carrying out the controls burden the user/violator. Furthermore, the following fines apply:

- A fine of 3,000-10,000 euros applies in the case someone has implemented a water abstraction/exploitation related work (e.g. opening a well) without having a valid permit to execute this work. The fine is imposed both on the owner as well as to the technical person responsible for the execution of the works.
- A fine of 3,000-5,000 euros applies in the case someone is abstracting water from a source without having a valid water use license for this specific purpose/source
- A fine of 500-5,000 euros applies in the case a licensed water user is violating the terms of use and obligations of its license (fine varies depending on the specific term and/or obligation violation)

2.1.6.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

In Perú, the Water Resources Regulation defines the Local Water Administrator [LWA] as the institution in charge to proceed against infractions, starting a sanctioning process that may even revoke the license [National Water Authority (ANA)]. The falls are related to the use of water for other usages, deviation of water, or exceed de volume of water defined in the license. Local User Boards inform about illegal abstractions or deviations to the LWA.

In Bolivia, the Ministry of Environment and Water manages the water distribution through different national authorities. For drinking water consumption, industrial and public use of water, coverage, level of service and monitoring of the operation of local water companies oversee AAPS [National Authority for drinking water and sanitation services], licenses to use water sources and volumes of exploitation are reported to AAPS by semester and yearly. For productive water use such as agriculture, there are regional [states called prefecture in Bolivia] and national authorities called SEDERI [Prefectural service of Irrigation] and SENARI [National service of Irrigation] respectively. They oversee approving licenses and checking for the development and monitoring of the operation of irrigation systems at regional and local levels. There are no water authorities at local level focusing on a hydrological jurisdiction specifically [watershed] like happens in Peru with ANA

2.1.6.6. Mahanadi River Basin (India)

In the case of illegal diversion of water from the surface water bodies (rivers, reservoirs and lakes) by the users within the state, the government can take legal action by filing law suits in the courts, as surface water resources are common property resources for which the government is the custodian. However, such actions are initiated only when the said diversion of water adversely affects the performance of the schemes owned by the government. In the rest of the cases, generally, there is a tendency to regularize the diversions by making the users pay a fee for abstracting the water. In the case of groundwater resources, the official (De jure) ownership of the resource is not well defined. But de facto, the person who owns the overlying piece of land has the right to use the groundwater, following the English Common Law tradition.

In the case of inter-state disputes over the use of water from a transboundary river basin (like what is now witnessed in the case of Mahanadi river basin), the affected parties can approach the Union government for dispute resolution. Under the Inter-state River Water Disputes Act (1956), a tribunal can be set up by the Union government for adjudication of disputes over water use. The tribunal, comprising of eminent judges (The Chief Justice of India, one sitting judge from the Supreme Court, and two more judges either from the SC or High Court) can allocate the surface water (and if required also groundwater) of the basin using the estimated yield (runoff) of the basin as the basis. The process can be very lengthy and time consuming. Several water disputes tribunals were set up in India in the past such as the Krishna Water Disputes Tribunal, Narmada Water Disputes Tribunal, Godavari Water Disputes Tribunals and Cauvery Water Disputes Tribunal which had already given their awards. If the affected parties (states) are not satisfied with the ‘award’ of the Tribunal, they can still approach the Supreme Court of India for review of the judgement, in case efforts for rapprochement fail.

Currently, there are five tribunals existing in India which are adjudicating disputes over water sharing. They are: Krishna Water Disputes Tribunal, Mahadayi Water Disputes Tribunal, Ravi-Beas Water Disputes Tribunal, Vansadhara Water Disputes Tribunal and Mahanadi Water Disputes Tribunal.

2.1.6.7. Murray-Darling Basin (Australia)

We are currently updating this data as it has not been reviewed since 2010 (se Bricknell, 2010). In summary, penalties range between a few hundred dollars and hundreds of thousands of dollars; although in most cases they do not exceed the market value of the water taken illegally.

2.1.6.8. Orontes River Basin (Lebanon)

The legal framework for protecting water resources in Lebanon has been established since 1925, but it has not been updated or supplemented with additional laws and application decrees. The Water Law of Lebanon, enacted in 1959, specifically addresses penalties for unauthorized water wells. In the Upper Orontes Basin, illegal water abstractions carry penalties, including fines of up to LBP 100 million (approximately 7,142 USD), imprisonment for up to 1 year, confiscation of equipment used for water extraction, and restoration of the water source to its original state. However, it remains difficult and challenging to detect and prove instances of water theft due to the lack of metering across all stations.

2.2. Stakeholder mapping & competences

This section will provide understanding of the overall governance regime, key water institutions and their roles including statutory powers.

2.2.1. Stakeholder mapping

Describe the current national and/or international aspects of water governance relevant for the scope of the project. Provide the following information: 1) governance structure (vertical v horizontal, centralized v decentralized, other); 2) Role of the different governance agents, and statutory powers (central government, regional institutions, local institutions, international agreements, other). Guide your description following the information for the Reno (Italy) living lab.

2.2.1.1. Júcar River Basin (Spain)

The Jucar River Basin has a centralized and vertical governance structure, where the main authority is the Jucar River Basin Authority (CHJ), a public body under the Ministry of Ecological Transition and Demographic Challenge. The CHJ is responsible for planning, managing and regulating water resources in the basin, as well as coordinating with other administrations and stakeholders. The CHJ has a participatory approach that involves different water users and civil society representatives in its decision-making processes. The central government sets the legal framework and the general guidelines for water policy in Spain (often transposing European directives and Frameworks), as well as supervises and supports the CHJ's activities. Regional governments have competences in water supply, sanitation, irrigation, environmental protection and land use planning within their territories. The Jucar River Basin covers four regions: Castilla-La Mancha, Valencia, Aragon and Murcia. Local institutions provide municipal services related to water, such as drinking water distribution, wastewater treatment and urban drainage. They also can collaborate with the CHJ and the regional institutions in water planning and management, although communication between local and regional/central authorities is often challenging.

Regarding water transfers between different regional or national administrations, the Jucar River Basin is part of the Tagus-Segura Transfer System, which transfers water from the Tagus River Basin (shared with Portugal) to the Segura River Basin (shared with Murcia) to meet water demands in the south-eastern coast of Spain.

Other governance agents include water users associations (mainly irrigation communities), environmental NGOs, research institutions, private companies and media. They participate in water governance through consultation, collaboration and advocacy mechanisms.

2.2.1.2. Nitra River Basin (Slovakia)

Slovakia has a unitary governance system, which is rather centralized, however, part of the competences are transferred to the eight self-governed administration regions including environmental matters such as adaptation to climate change. The lower level of governance within these regions are the district authorities who are responsible for executing the national legislation in regards to the environment.

The government, and in particular the Ministry of Environment (henceforward "The Ministry"), is responsible for legislative framework and for setting up and implementing the strategies for water management at the national level, while ensuring compliance with the EU legislation. The expert institutions involved in water management under the Ministry, which are Slovak Water Management Enterprise (SVP), Hydrometeorological Institute (SHMÚ), and Water Research Institute (VÚVH), support the Ministry, who coordinates legislation and strategies implementation in accordance with the national and EU law. The Ministry also coordinates the regional and local authorities.

Ministry of Environment also ensures that Slovakia, as an EU member state, transposes and implements the EU water-related legislation into the national legislation. The EU's Water Framework Directive was transposed into the national legislation through the Water law Act No. 364/2004 Coll. The Water law defines the institutions and their responsibilities in water resources management, protection, and monitoring; i.e. who is responsible for monitoring of the quantity and quality of the surface and groundwater, water management planning, management of the water courses and reservoirs, payments for water use, water infrastructure, etc. Water Plan of the Slovak republic (Water Plan, RBMP) is the instrument to achieve the objectives of the Water Framework Directive and is updated every six years. The current Water plan runs through 2022 - 2027 and consists of the Danube and Vistula RB. Another important law is the Act nr. 7/2010 for protection against floods, which transposes the Directive of the European parliament and the Council 2007/60/ES of 23 October 2007 on the assessment and management of flood risks.

The Ministry of Environment coordinated the process of developing a new *Concept of water policy of the Slovak republic for 2030 with an outlook to 2050* (henceforward "Water Policy 2030"), which is a strategic document that integrates national planning instruments and supports the integration of water policy objectives into all sectoral policies. The Water Policy 2030 sets specific objectives, measures, and indicators for those objectives within ten areas: water in landscape, water in settlements, sustainable water use, water for all citizens, clean water, living rivers, the Danube River, understanding water, responsible and informed water management, and water as a strategic investment. The objectives, measures, and the related indicators are consistent with the Water Plan and other strategic policy documents related to water protection, management and use, in particular with the Development Plan for Public Water Supply Systems and Sewerage Systems and with the Flood Risk Management Plan.

The common basis of the water policy is to achieve the environmental objectives, i.e. achieving good status of the water.

Slovak Water management Enterprise (SVP) is the authority appointed by the Ministry of Environment and responsible for water management and planning in the six main river basin districts in Slovakia including Nitra river that belongs to the Lower Váh RB authority. SVP works with the national, regional, and local authorities and other stakeholders to develop a water management plan in each of the six RB. SVP is mainly responsible for management and protection of the rivers and other water bodies within the basins, hydro plants, protection of the drinking water reservoirs as well as the water supply from these reservoirs and other water courses. SVP works to maintain the sufficient water level in the ecosystems and works to restore and protect important biotops such as wetlands, old river channels, etc. SVP is partially responsible for monitoring of the surface water quality, and protection of the areas of natural water accumulation according to the Act 305/2018 Coll. Another important responsibility is flood prevention.

The distribution of the responsibilities among the other institutions involved in the water management and monitoring is rather complex. For example, while SHMÚ is responsible for monitoring the water quantity, it also compiles annual reports on the quality of the surface waters and water balance, which is coordinated with the WRI and SVP, while the SAŽP is responsible for reporting the data according to EU legislation. SHMÚ and WRI are responsible for hydromorphological monitoring. WRI oversees an ecological and chemical assessment of the surface waters on a continuous, as well as 6-yr, basis. The latter is used to update the Water Plan, which runs on a 6-yr basis.

Beside the Ministry, other governmental authorities involved in the water management include the district authorities (belonging to the Ministry of Interior), Slovak Environmental Inspectorate (SEI), and towns. The responsibility of the district authorities in respect to water management include giving permissions for water use rights, nature and biodiversity protection, prevention against floods, EIA, administrative procedures, trying offences of the Water Act. The district authority can also change, limit, or put a ban on the water abstraction from the surface water bodies. The Nitra RB is located within the Trenčín self-governing region and the study site is located within the Prievidza district. The SEI acts as the main controlling body overseeing the compliance with the Water Act. This includes controlling the waste water treatment and release, protection of the water, it sees that the decisions by water manager (SVP) in regards to water use and management are followed. Ministry of Agriculture and Rural Development is in charge of assigning water sources that can be allocated for irrigation and defining the rules for irrigation water. State Nature Conservancy (ŠOP SR) is the agency of the Ministry of Environment responsible for the protected areas, including wetlands, rivers, lakes, forests within these areas.

2.2.1.3. Reno River Basin (Italy)

Italy's governance system is a hybrid of both unitary and federal state, with a vertically decentralised structure. The Italian constitution grants significant autonomy to the subnational governments of the self-governing regions and autonomous provinces. These regions and provinces have their own elected governments and legislatures and are responsible for a wide range of policy areas, including water governance. This decentralization has led to a complex and fragmented system of responsibilities for managing and governing water resources, which is articulated at the national, regional, and local levels.

The central government is responsible for establishing a national legislative framework and strategic objectives for water management, as well as ensuring compliance with EU directives on water and sanitation. The Ministry of Environment1 sets policy direction, coordinates with regional authorities, and implements the national framework. The Ministry of Agriculture develops policies and strategies for land reclamation, irrigation, and rural development. The Ministry of Infrastructure oversees planning, construction, and maintenance of water infrastructure projects, including dams, reservoirs, treatment plants, distribution networks, and flood control. Additionally, the Inter-ministerial Committee for Economic Programming for Sustainable Development (CIPESS) plays a role in coordinating inter-ministerial efforts for sustainable development.

Italy, as an EU member state, is compelled to transpose and implement EU water-related legislation into its national legislative framework. The Water Framework Directive is the EU's primary legislation for safeguarding water resources, and it has been incorporated into Italian law through the Environmental Code, or Legislative Decree No. 152 of 3 April 2006. This Code established a single, coherent legislative framework and streamlined the legal and administrative procedures for environmental protection, including water resource management. The legislation also provided for the establishment of river basin districts and their corresponding authorities, reforming the previous system.

There are seven river basin districts in Italy, each with its own River Basin Authority (RBA). The RBAs are responsible for coordinating water management policies and practices in their respective districts, ensuring compliance with water legislation and promoting sustainable water use. The RBAs work closely with regional authorities, local communities, and other stakeholders to develop and implement integrated water management plans. They also monitor water quality and quantity, manage water allocation and distribution, and coordinate flood risk management efforts. RBAs play a coordination role. Its statutory bodies include the Permanent Institutional Conference as a decision-making body of the Authority, which consists of Ministers and Presidents of Regional Councils, chaired by the Minister of Environment. Its tasks include adopting criteria and methods for drafting the basin plan, defining times and methods for plan adoption, coordinating water recovery and protection plans, controlling plan implementation, and adopting safeguard measures until the plan is adopted.

Regions have competences in a range of areas related to water governance, such as monitoring and assessing water quality, regulating water use, and promoting sustainable practices in agriculture and industry. They also oversee the management of regional water authorities and coordinate with national and local authorities to ensure effective water management. Central government or regions also establish water boards2 which are public entities oversee the construction and operation of water infrastructure such as dams, canals, and treatment plants, and work to prevent pollution and degradation of water resources.

Italy boasts a long history of land reclamation, especially in low-lying plains that were once characterized by wetlands and coastal marshes. This legacy has led to the development of an extensive network of drainage and irrigation channels that safeguard the highly developed lowlands and support the irrigation of vast agricultural fields. As a country dominated by mountains, Italy is home to an extensive system of natural and regulated lakes, along with man-made water reservoirs, which contribute to its comprehensive water infrastructure. To manage, maintain, and enhance these water infrastructure systems, different types of water boards has been established. The water boards hold responsibility for the governance of natural and man-made water bodies, as well as for land reclamation and irrigation. The governance of these water boards is regulated by distinct legislation, ensuring proper management and sustainability of Italy's vital water resources. Water boards have the authority to levy charges and taxes on water users in their respective areas of responsibility. These charges and taxes are intended to cover the costs of providing water services and maintaining water infrastructure, as well as to fund investments in new infrastructure and environmental protection measures.

Water supply and sanitation (WSS) services in Italy are divided among national, regional, and local government bodies, operating within designated service areas. Both private and public companies owned by local authorities manage Italy's water supply. ARERA, the Italian Regulatory Authority for Energy, Networks, and Environment, oversees water and sanitation service providers by regulating tariffs, defining quality standards, and monitoring compliance. Fair and transparent tariffs take into account infrastructure investments, operational costs, and environmental sustainability. The authority enforces quality standards to provide consumers with reliable, safe, and high-quality services, while safeguarding consumer rights through complaint resolution, rights promotion, and encouraging regulatory process engagement. In recent years, Italy has seen a trend towards greater consolidation of water and sanitation services. Smaller and medium-sized companies have merged with larger ones to achieve economies of scale and enhance efficiency. Italy has made significant progress in recent decades, achieving nearly universal coverage in urban areas and substantial improvements in rural areas. Often, the same utilities manage both water supply and sanitation services, but separate companies may be responsible in some cases.

Stakeholder participation is a key aspect of water governance in Italy. Water user associations and other local organizations play an important role in managing water resources. There are numerous civil society organizations that work on water-related issues, including environmental protection and water conservation. Italy has a history of negotiated environmental agreements, such as river, coast, or aquifer contracts, that promote sustainable water management practices through participatory approaches involving local governments, water users, environmental organizations, and other stakeholders. These contracts establish a shared vision for managing water bodies, including goals and actions related to water use, conservation, and protection, and measures for monitoring progress towards those goals.

2.2.1.4. Tympaki River Basin (Greece)

The Greek Law was harmonised with the Water Framework Directive (WFD, 2000/60/EC) with Law 3199/2003 (Government Gazette 280/A/2003) and the Presidential Decree 51/2007 (Government Gazette 54/A/2007). The country was divided in 14 River Basin Districts (RBDs), defined according to No.706/2010 Decision of the National Water Committee (GG 1383/B/2010 and GG 1572/B/2010 - correction of Annex II) and River Basin Management Plans (RBMPs) have been developed for each of the 14 RBDs following the provisions of the WFD. The 1st River Basin Management Plan for the Crete River Basin District (EL 13) was approved by the Decision No. 163/31.03.2015 (GG 570/B/2015) of National Water Committee and concerned the 1st Management Cycle (2009-2015). The 1st Revision was approved in 2017 (Government Gazette approving the 1st Revision of the RBMP for the Crete RBD: 4666/B/29.12.2017), while the 2nd revision is currently in progress.

At the national level, the competent authorities for the protection and management of water resources are defined by Law 3199/2003 (GG 280/A/2003), as amended and in force, for the Protection and Management of Water Resources, which harmonizes the National Law with the provisions of the WFD. The competent authorities are:

The National Water Committee is defined as the high level interministerial body and has the responsibility of policymaking for the management and protection of water resources of the country and consists of the Ministers of: (a) Environment and Energy, as President, (b) Infrastructure and Transport, (c) Economy, (d) Economy and Development, (e) Interior, (f) Health, (g) Rural Development and Food, (h) Administrative Reconstruction. In the Committee other Ministers may participate, after invitation of the President, if issues of their responsibilities are discussed, while the Minister of Foreign Affairs participates when issues regarding transboundary water bodies are discussed.

The National Water Council, delivers opinions to the National Water Committee for national programs related to the protection and management of the water resources of the country, while takes note of the Yearly Report, which the National Water Committee submits, regarding the status of water environment of the country, the implementation of the legislation for the protection and management of water resources, as well as the compatibility of Union's acquis. It consists of 26 members (parties and bodies representatives) and the Minister of Environment and Energy. The National Water Council is convened from its President at least once a year.

The Special Secretariat for Water (SSW) of the Ministry of Environment and Energy, which has the responsibility of the implementation of the Programs for Protection and Management of Water resources of the country and the coordination of agencies and national bodies for each issue regarding the protection and management of water resources. The provisions of its creation and definition of competencies are defined by Law 3199/2003 (GG 280/A/2003) for the Protection and Management of Water Resources, as amended and in force, specially by Law 4117/2013 (GG 29/A/2013) and Law 4315/2014 (GG 269/A/2014), and the Presidential Decree 132/2017 (GG 160/A/2017) "Organization of the Ministry of Environment and Energy" in combination with the JMD 322/2013 "Organization of the Special Secretariat for Water of the Ministry of Environment, Energy and Climate Change" (GG B' 679), as in force. The Secretariat, in collaboration with the Water Directorate of the Decentralized Administrations, sets up the national programmes for the protection and management of the water resources of the country and monitors and coordinates their implementation.

Additionally, on implementation issues of the WFD, the following Ministries are engaged: Ministry of Foreign Affairs, Ministry of Rural Development and Food, Ministry of Infrastructure and Transport, Ministry of Economy and Development, Ministry of Health, Ministry of Maritime Affairs and Island Policy, Ministry of Interior.

At a regional level, the competent authorities are:
The **Water Council of the Decentralized Administrations**, which, according to Article 6 of Law 3199/2003, as amended by Article 53 of Law 4423 (GG 182/A/2016), is established in each Decentralized Administration as an instrument for social dialogue and consultation on water protection and management issues. In case that the River Basin Management Plan is implemented by the Decentralized Administration, the Water Council of the Decentralized Administration is consulted before the approval of the Management Plan and advices Secretary General of the Decentralized Administration [or otherwise the Coordinator of Decentralized Administration, according to article 28 of Law 4325/2015

(GG 47/A/2015)] on every issue of water protection and management that he/she submits. Also, in this case, the Water Council of the Decentralized Administration, before issuing its opinion to the Management Plan, shall make it available, in order for the public to be informed of its content and participate in the consultation about it, within a deadline set by the Water Council.

The Water Directorates of the Decentralized Administrations (WDC), through which the Decentralized Administration's responsibilities for the protection and management of water are exercised. Law 3199/2003 (GG 280/A/2003) for the Protection and Management of Water Resources, as amended and in force, specially by Law 4117/2013 (GG 29/A/2013) and Law 4315/2014 (GG 269/A/2014). The rovisions for their creation and definition of competencies are defined by the: Presidential Decree 51/2007 for the definition of measures and processes for the complete protection and water management, according to the Directive 2000/60/EC; the Presidential Decree 136 (GG 229/A/2010) "Organization of the Decentralized Administration of Crete", the Decision of the National Water Committee 706/2010 (GG B' 1383/2-9-2010 "Definition of the River Basins of the country and of the competent Regions for their management and protection" and GG B' 1572/28-9-2010 correction of Annex II), as in force after the approval of the individual River Basin Management Plan of the country's River Basin Districts.

In addition, Local Administration Authorities of Level A and B are involved in issues regarding the implementation of the WFD. The competent authorities at the national, regional and local levels are presented in the figure below:

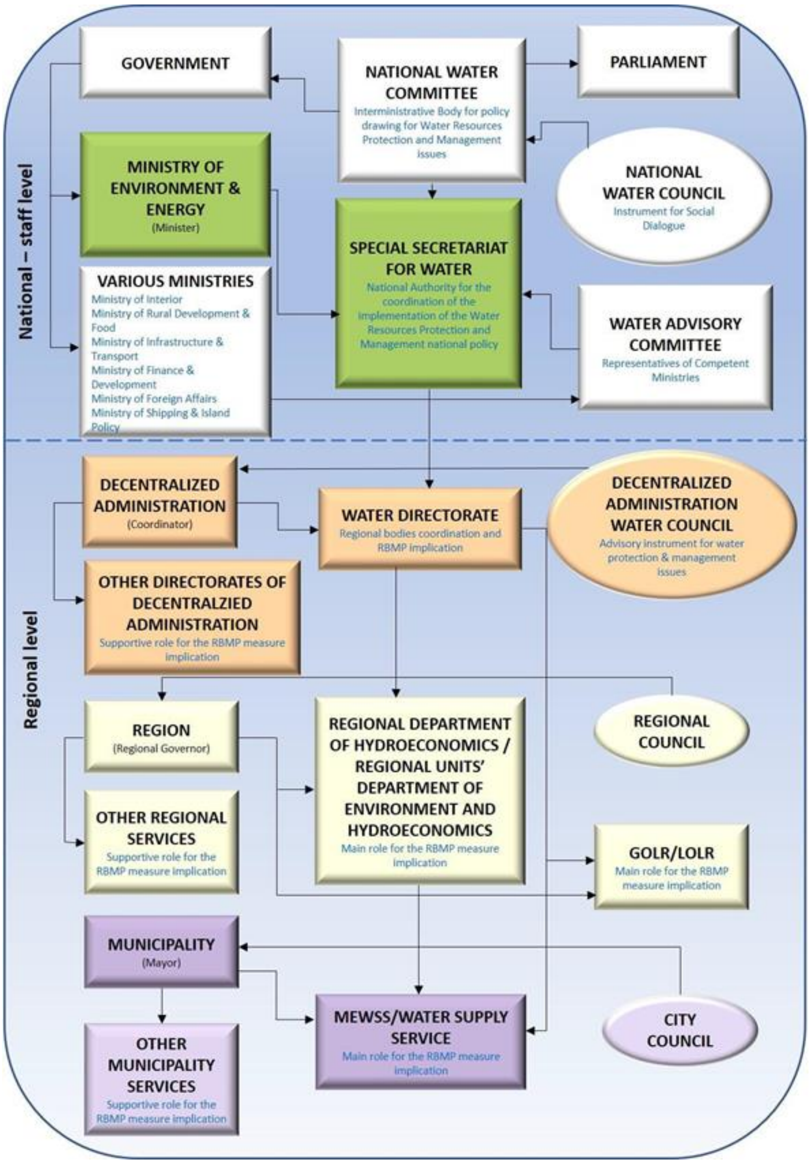


Figure: The competent authorities at the national, regional and local levels in Greece

In line with the above structure, a complete mapping of the stakeholders in the Tympaki basin, along with their main roles and competences, is presented in the Table below:

Table: The stakeholders' community in the Tympaki basin (organisation, roles and competences)

Organization	Theme	Specific roles / competences
Region of Crete – Directorate of Environment and Spatial Planning – Department of Hydroeconomy	Protection and management of water resources	▪ Responsible for the design and construction of infrastructure/ water works (dams, wells, water supply and distribution systems). Once these works are completed, the Region of Crete constitutes a local land reclamation organization (TOEB) to operate and maintain the system and to provide water to farmers. ▪ Design and implementation of measures ▪ Decisions on water use restrictions

		▪ Pollution monitoring and environmental protection (e.g. ecological flows, good water quality status, etc.).
Region of Crete - Directorate of Technical Works	Construction of infrastructure, water works	▪ Responsible for the construction and maintenance of the dams ▪ Responsible for the water allocation system
Region of Crete - Directorate of Agricultural economy & Veterinary	Regional agricultural development	▪ Responsible for the development of the Regional Agricultural Development Plan
Water Directorate of Crete Decentralized Administration (WDC)	Protection and management of water resources	▪ Main role in the development and implementation of the WFD River Basin Management Plans (RBMPs) and Programme of Measures ▪ Responsible for issuing water use licenses: the water in Greece is considering as a public domain good and every user has to issue a license. The license describes the terms and conditions to use the water, the specific amount/volume of water to be abstracted and used within specific time (usually 10 yrs) ▪ Monitoring and data collection ▪ Regulation enforcement ▪ Coordination of stakeholders and public participation
Water Council of the Decentralized Administration	Social dialogue and consultation on water protection and management issues	▪ Promotes and supports consultation with the general public and the various stakeholders, and dialogue with the civil society
Special Secretariat for Water (SSW) of the Ministry of Environment and Energy	Protection and management on the water resources	▪ National focal point for the WFD ▪ Responsible for the development and implementation of the National Programs for the Protection and Management of Water Resources of the country, and the coordination of agencies and national bodies regarding the protection and management of water resources
Local Land Reclamation Organization -	Irrigation management and operation of irrigation water works	▪ Responsible to operate the water supply and distribution system for local farmers (i.e provision of irrigation water to the farmers),

TOEV of Zone A' of Messara		including the maintenance of the pipeline network. ▪ Responsible to cover the full operational costs ▪ Collection of the water fees from the connected agricultural users / monitoring of the instralled water meters
Municipality of Phaistos– Technical Services Department	Water supply for domestic use, municipal wastewater treatment	▪ Responsible for the design of the domestic water supply system to cover domestic and touristic water use ▪ Responsible for the design of the sewage system
Municipal Water Supply and Sewerage Company of Faistos (DEYA Faistos)	Water supply, wastewater treatment	▪ Responsible to construct, operate and maintain the domestic water supply and sewage systems (i.e. supply water for domestic use and also for the tourist activities - resorts, hotels, etc.) ▪ Responsible for wastewater collection and treatment ▪ Cost recovery and collection of water fees from the users ▪ Analysis and monitoring of drinking water quality
Hellenic Survey of Geology & Mineral Exploration (EAGME)	Monitoring system, R&D in groundwater management and exploitation	▪ Responsible for the monitoring system of the groundwater ▪ Research for water development
Agricultural School of Messara (under the auspices of ELGO-DIMITRA and the supervision of the Ministry of Rural Development and Food)	Education, training	▪ Education ▪ Capacity building and training of farmers ▪ Dissemination of best agricultural practices
Individual Farmers	Irrigation water	▪ Construction and operation of private wells for agricultural use, after having issued a valid water license from the WDC

The Tympaki basin basin, located in the central-south area of Crete Island, constitutes one of the most important agricultural regions of Crete. Groundwater abstraction is causing a drop in the water table of due to overexploitation in some areas, as well as seawater intrusion, while nitrates pollution is present is some location. As such, water supply and allocation, sustainable management of the irrigation water, limiting overexploitation (and its adverse impacts) and controlling nitrates pollution are of main concern in the basin. In this respect, we have identified 4 key stakeholders with high influence and interest, as presented below:

- The Region of Crete, with a direct interest in the protection and management of water resources. As the Region of Crete bears the responsibility for the design and construction of infrastructure/ water works (dams, wells, water supply and distribution systems) it has a high influence on the overall water supply and allocation. It is also responsible for the design and implementation of measures, such as water use restrictions among others. Finally the Region of Crete is responsible for pollution monitoring and environmental protection (e.g. ecological flows, good water quality status, etc.), as well as for the development of the Regional Agricultural Development Plan. It is thus a stakeholder in a position to strongly influence decision-making and planning.
- The Water Directorate of Crete Decentralized Administration (WDC), with a direct interest in the proper implementation of the WFD River Basin Management Plans (RBMPs) and related Programme of Measures. As the WDC bears the responsibility for issuing the water use licenses it has a high influence on controlling groundwater abstraction and overexploitation.
- The Local Land Reclamation Organization (TOEV of Zone A' of Messara) hasa direct interest on efficiently meeting irrigation water demand. This organization (TOEV) bears the responsibility of providing sufficient irrigation water to the farmers, as well as adequately operating and maintaining the irrigation water supply and distribution systems, including cost recovery. Among others TOEV defines the water tariffs for the farmers, is responsible for the collection of the water fees from the farmers and the monitoring of their water meters, monitors the levels of its pump stations, set irrigation rules. As such, the TOEV has a high influence on irrigation water supply and management, and on the Tympaki water productivity noting that agriculture is the dominant water use.
- The Municipal Water Supply and Sewerage Company of Faistos (DEYA Faistos) has a direct interest on the provision of adequate domestic water and wastewater treatment. As DEYA Faistos bears the responsibility to collect and treat domestic wastewater it also has an influence on irrigation water supply through the provision of treated wastewater for agricultural reuse.

2.2.1.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

The Autoridad Nacional del Agua [ANA], is the national authority for water management in Peru. It is an entity under the Ministry of Agriculture and Irrigation that exercises the technical and normative authority to ensure the integrated, sustainable and multisectoral management of water resources for the benefit of water users and the general population. It was created in 2008 by Law No. 29338, the Water Resources Law12. ANA operates at different levels: national, regional and local. It has 14 decentralized bodies called Autoridades Administrativas del Agua (AAA), which are responsible for directing and executing water management in their territorial areas. Each AAA has one or more Administraciones Locales del Agua (ALA), which are the units that administer water resources and their associated goods at the local level. There are 65 ALAs in total in all Peru, three of them are related to Caplina, Maure, and Desaguadero. ANA Peru also has a digital platform called "Observatorio del Agua", which provides interactive information on water resources, such as statistics on water demand by basin, projects for formalizing water use, historical reservoir levels, inventory of wells and other data.

Ministry of Environment and Water in Bolivia (MMAyA) is the government entity responsible for water and sanitation policies, regulation, and investment. It was created in 2009 by Supreme Decree No. 29894, as part of the constitutional reform that recognized water as a human right and a common good in the country. MMAyA's mission is to promote equitable development, reciprocal and in harmony with the environment, through the integrated management of water resources, access to drinking water and sanitation, irrigation for food security, as well as the integrated management of the environment and life systems. MMAyA operates at different levels: national, regional, and local. It has 3 vice-ministries that cover different areas of water and environment management, such as water resources and irrigation [VRHR], drinking water and sanitation [VAPSB], and biodiversity, climate change, environmental quality, planning and coordination [VMA]. There are 14 prioritized hydrological regions in which they are initiating the development of regional water authorities, up to now only one is operational [water authority for Katari Basin which is part of the hydrological system of Titicaca Lake].

Dirección General de Aguas [DGA] from Chile is a public entity under the Ministry of Public Works that is responsible for promoting the water resources management and administration in a sustainable framework, public interest, and efficient allocation. It was created in 1975 by Supreme Decree No. 575, as part of the institutional reform of the water sector that introduced a market-based system for water rights allocation. DGA's main functions are to provide and disseminate the information generated by their hydrometric network, to exercise the police and surveillance of natural channels and water users' organizations, to ensure the environmental role of water resources and to contribute to improving the people's life quality, and to promote sustainable and equitable water resources use through the provision of indicative planning and general information. DGA operates at different levels: national, regional, and local. It has a central office in Santiago and 15 regional offices throughout the country, one is related to the Mauri-Caquena River. It also has 101 hydrological stations that monitor surface water quantity and quality, and 1,200 piezometers that monitor groundwater levels and quality.

The Autonomous Binational Authority of the Lake Titicaca [ALT by its acronym in Spanish] is an entity of public international law that depends on the Ministries of Foreign Affairs of Peru and Bolivia, and it is coordinated with ANA in Peru and MMAyA in Bolivia. It was created in 1996 by a binational agreement between the two governments to promote and conduct actions, programs and projects for the conservation, control, and protection of the water resources of the TDPS Water System (Titicaca, Desaguadero, Poopo and of Coipasa Salt lakes) within the framework of the Binational Global Master Plan (PDGB) published in 1992 by the two governments. The ALT has a headquarters in La Paz, Bolivia, and two executive directorates in Puno, Peru, and Oruro, Bolivia. Some of the issues related to the agreements required between Bolivia and Peru are the management of water resources, the preservation of biodiversity, the prevention of pollution, the promotion of sustainable development, and the strengthening of cooperation and integration. ALT is a binational institution between Peru and Bolivia, but it does not have a relation o legal link with DGA or any other Chilean institution so far.

[1] https://www.gob.pe/ana

2.2.1.6. Mahanadi River Basin (India)

In the case of Mahanadi river basin, there are several agencies concerned with water resource evaluation and planning, water resources development, water supplies and water resource management in Chhattisgarh. They include: Water Resources Department, state watershed management authority; Public Health Engineering Department, groundwater department, the State Pollution Control Board at the state level, and Central Water Commission, and Central Ground Water Board at the union level.

The overall governance is still provided at the provincial level by the governments of Odisha and Chhattisgarh. The governance and management of surface water is provided by the State Water Resources Departments of the respective states. The powers and responsibilities for investigation, planning, design, execution and operation & maintenance of water resources projects (mainly reservoirs and diversion systems) based on surface water (rivers and lakes) are vested with the state water resources departments.

There are a total of 237 reservoirs belonging to minor, medium and major category in the entire basin. This includes some reservoirs of schemes that are still not operational. But, those with gross storage capacity less than 25 MCM constitute nearly 90 per cent (206 nos.) of the reservoirs. Together, they account for only 4.2 per cent of the live storage capacity (587.6 MCM) available in the basin.

The Water Resources Departments are concerned with inter-sectoral water allocation, especially to meet the water needs of industries and (rural & urban) domestic sector. The State Public Health Engineering Departments of the respective states are concerned with rural water supply provisioning. They develop groundwater resources for rural drinking water supply by undertaking drilling of wells.

The hydrological monitoring of the river basin is carried out by the Central Water Commission which maintains 39 stream-gauging stations across the river and its tributaries for water level recording, discharge measurement, measurement of sediment, and monitoring of water quality. The State Water Resources Departments maintains the reservoir mass balance data for the various major and medium reservoirs built by them in the basin.

Groundwater monitoring is carried out by the Central Ground Water Board, which maintains a total of around 900 observation wells across the basin. Groundwater levels are recorded four times a year and groundwater resource assessment is done once in every year based on water level fluctuation approach to estimate recharge from rainfall.

One of the biggest governance issues today is that rules relating to planning, development, allocation and management of water resources are being or can be framed at various levels and by various agencies. At the state level, the water resources department carries out planning of water resources development activities in different river valleys, including the Chhattisgarh part of Mahanadi river basin. In the absence of any exclusive institution at the state level, the state WRD also frames rules relating to the extent to which the resources within a basin can be appropriated. The state WRD can also frame rules on allocation of water from the schemes already developed across different water use sectors (agriculture, industry, municipal use and rural domestic use) based on the criteria it evolves.

While WRD is the largest player, different line agencies concerned with water supply such as the State PHED and State Industrial Department also separately develop water resources (both surface and groundwater) to meet their sectoral requirements. They do not take cognizance of how such appropriation affects other sectors, which are dependent on the same water resources. There is already a growing dissent amongst farmers and fishing community over contracting of a private firm for developing one of the tributaries of Mahanadi for allocating water to an industrial area by Chhattisgarh State Industrial Department.

At the same time, the several hundreds of village Panchayats in the states also can frame rules relating to the degree of development of surface water resources in their locality. Under the Panchayati Raj Act, passed through the 72nd Constitutional Amendment, the PRIs (Panchayati Raj Institutions) enjoy powers with respect to development and management of surface water resources, within their administrative boundaries, and can frame rules in respect of these. Even the legally registered NGOs (societies and public Trusts) can undertake planning, development and management of small water harvesting/harnessing schemes, and watershed development activities in villages, even without the written permission of the Panchayats, so long as no objections are raised by the governing body of the Gram Panchayat to such activities. This is because there is no clarity on who (within a state) can frame rules relating to all aspects of planning, development, and operation and maintenance of water resources development and management projects. Or in other words, rules are framed at various levels.

Under the programme launched by the Ministry of Drinking Water and Sanitation to develop Water Safety and Security Plans for villages, the Gram Panchayats are entrusted with the responsibility of water resource evaluation (groundwater assessment at the GP level); water supply planning, including water budgeting; and selecting technologies for village level water supply. The methods and tools for resource monitoring and evaluation, water budgeting, and even procedure/process to be followed for water supply planning are all provided by the Ministry guidelines (see, WSP (2015)), and even tool kit also exist for preparation of drinking water security plan for villages. This is probably in recognition of the startling reality that the GPs in most situations do not have the technical capability to determine the criteria for resource evaluation and planning.

A quick review of the methods used for resource evaluation and water budgeting shows that there are simply crude and highly unreliable. While GP is the unit for groundwater assessment, there is no scientific consideration in taking this as the appropriate unit for resource evaluation and planning. Further, the methodology for resource evaluation & planning and the selection of water supply technology have weak scientific basis. The estimation of natural groundwater recharge (annual groundwater availability) and water consumption in crop production, two crucial planning variables, are based on ad hoc norms. The net result is over-estimation of the resource base, unrealistic estimates of irrigation water use in different sectors. The process of selecting technology for water supply gives due consideration to the institutional capability of the GP to run the scheme, rather than the physical sustainability of water supply (source: based on a review of WSP, 2015). The only consideration in choosing these methods seems to be that the GP level Water Supply and Sanitation Committee should be able to undertake groundwater assessment, water budgeting and water supply planning exercises and run the schemes so designed.

Given the fact that Mahanadi is an inter-state river basin, the allocation of water from the basin by the upper riparian state is already in a contested terrain. With rapid industrialization sweeping the state of Odisha, every industry which wanted to set up manufacturing units along Mahanadi rive was promised water from it, and by 2012, the river water accounts for nearly 62% of the total water allocation by the water resources department for industries in the state, while it was only 13% five years ago (source: Down to Earth, 29 February, 2012). In fact, since 2006 tension has been building up between the water resources department and the local governments and farmers over the government's decision to increase allocation of water from Hirakud dam for industries. Given this scenario, Odisha has begun to raise opposition to Chhattisgarh's plan to build more diversion systems in its territory. The government of Odisha has already approached the Ministry of Water Resources of Government of India to set up a tribunal for adjudication of water allocation from the basin.

In a meeting held in the Ministry of Water Resources, Govt. of India between the representatives of the two states, the Chief Minister of Odisha expressed the opinion that the work on all ongoing projects in Mahanadi basin in Chhattisgarh state should be stopped for three months and an Expert Committee may be formed to study the impact of projects in Mahanadi basin and give its report within three months. However, the contention of the CM of Chhattisgarh is that the River has sufficient water to meet the requirements of both the states and that 57% of it is still flowing into the Ocean un-captured. Further, Govt. of Chhattisgarh stated that most of the ongoing projects were started 10 years back and they are in their final stages of completion. Hence, it is not possible to stop the construction work on these projects. The govt. of Chhattisgarh wanted a Joint Control Board for monitoring water diversions in the basin.

The meeting decided to set up a Special Committee under the chairmanship of Dr. Amarjit Singh, the then Secretary-Water Resources. The Committee was to list out the water resources projects in Odisha and Chhattisgarh those have been constructed or are under construction without the approval of Technical Advisory Committee (TAC) of Mo WR, RD & GR. Different teams will be sent to these states for this work. Hon'ble Union Minister had asked the states to put on hold the project construction works for one week. It was also decided that the gauge and discharge sites will be opened at inter-state border of Odisha and Chhattisgarh at a location, for effective measurement of flows from Chhattisgarh catchment into Hirakud dam.

Subsequently, a tribunal had been set up in March 2018 to adjudicate the dispute over sharing of water from the Mahanadi basin between the two states, on an appeal from the government of Odisha to the Ministry of Water Resources, River Development and Ganga Rejuvenation, Govt. of India.

2.2.1.7. Murray-Darling Basin (Australia)

MDB water governance is complex. Horizontal governance is seen in the relationships between: i) federal (e.g. MDBA, Commonwealth Environmental Water Holder [CEWH], Department of Climate Change, Environment, Energy and Water [DCCEEW]), ii) state agencies (e.g. South Australian Department for Environment and Water [SA-DEW]), iii) state irrigation infrastructure operators (IIOs) such as Goulburn-Murray Water (GMW) which allocate, deliver, apply fees/charges and monitor water supply/uses, and iv) local governance agencies (e.g. Council organizations) which may be responsible for flood damages and road closures during environmental watering events. Vertical governance occurs at state and federal levels as well, where apart from MDBA and DCCEEW the Office of the Inspector-General of Water Compliance (IGWC) is responsible for compliance and enforcement (Australian Parliament, 2021a), the Bureau of Meteorology (BoM) tracks water use data and reports annual statistics, the Australian Consumer and Competition Commission (ACCC) monitors trade regulation and larger assessments of performance/issues, and the Commonwealth Scientific and

Industry Research Organisation (CSIRO) delivers science and climate modelling advice to users across the Basin.

As stated previously, powers over water accrue to state governance agencies only under Sec. 100 of the Australian Constitution, and the federal government has no powers or say over water management—except via the joint-agreement between the Basin states for collectively managing the MDB area as a Basin that spans multiple state boundaries (Loch and Gregg, 2018). This provides for a tenuous and political context to MDB water management, where some jurisdictions use this tension to secure advantages from time to time.

Water supply and delivery also occurs under this sharing agreement, where federal (MDBA), state (e.g. the Victorian Department of Energy, Environment and Climate Action [V-DEECA]) agencies and local IIOs such as GMW all play roles in the process of allocating water each year across rights, storing water and measuring/managing carry-over where available (i.e. water not used in one year, carried forward for use into the next water year less evaporation), delivering water orders, and monitoring extraction and use as per license conditions.

Finally, the MDB is also a signatory to the Ramsar Wetland Convention as a motive to monitor and enforce their protection and management for ecological good under international terms—offering some good opportunities in the past to sidestep political interference and walk-backs.

2.2.1.8. Orontes River Basin (Lebanon)

Governance structure: In Lebanon, the governance structure for water management involves a mix of centralized and decentralized approaches. The central government, particularly the Ministry of Energy and Water (MoEW), plays a significant role in formulating policies, setting regulations, and providing overall direction for water management. Regional institutions, such as water establishments and basin authorities, operate at the local level and are responsible for implementing water management activities within their respective regions. The overall authority over the water sector at the national level falls under the Ministry of Energy and Water. The operational authority at the regional level is exercised by five public water utilities: Beirut and Mount Lebanon Water Establishment, Beqaa Water Establishment, North Lebanon Water Establishment, South Lebanon Water Establishment – collectively known as the Regional Water Establishments (RWEs), and the Litani River Authority (LRA).

The Ministry of Energy and Water (MoEW) is the main government agency responsible for water governance and management in Lebanon. The MoEW holds statutory powers in terms of policymaking, regulation, and strategic planning for water resources and infrastructure development. It formulates national water strategies, develops master plans, and oversees the coordination and management of water resources at the national level.

The RWEs are given autonomy and responsibility for the planning, building, operating, and maintaining all potable and irrigation water transmission and distribution networks, along the sewage treatment plants collection networks within their respective areas of jurisdiction. They are also mandated with recommending water tariffs and wastewater charges based on the prevailing socioeconomic conditions in the operational regions. The LRA is mandated to plan and operate all potable and irrigation water networks. Measuring all surface flows throughout the country and establishing and managing and operating hydroelectric power plants on the Litani River.

In addition to the MoEW, the RWEs and the LRA, there is a significant number of public sector actors involved, including the Ministries of Public Health, Environment, Agriculture, Industry, and Interior, in addition to the Council for Development and Reconstruction (CDR). Municipalities and governorates are responsible for collecting water tariffs, maintaining water infrastructure, and providing water services to their residents.

2.2.2. Stakeholder competences – focus on modeling

Identify 1) the key models used to inform water resources management in your lab; and 2) the stakeholders responsible of managing these models (only the stakeholder name – a more detailed narrative of each stakeholder is required in Section 2.2.4)

LAB	**Climate system**	**Agronomic System**	**Hydrological System**	**Water Resources System**	**Microeconomic System**	**Macroeconomic System**	**Other relevant systems**
Italy - Reno RB	a). Climate projections made available in the project; 1b)2. Climate projections constructed through statistical downscaling technique based on Perfect Prog approach (CCAReg scheme) applied to large scale patterns simulated by GCMs from CMIP5 experiment in the framework of	a) Criteria model (water balance model based on soils, crops and meteorological data) https://github.com/ARPA-SIMC/CRITERIA1D 1b) IRRINET https://consorziocer.it/it/strumenti/irrinet/ based on meteorological data, pedological data and groundwater data 2) Canale Emiliano Romagnolo for IRRINET irrigation system		1a) Topkapi mode for the hydrological description, Tpk coupled with HEC-RAS for the hydraulic system 1b) Topkapi-Sobek chain 2) Arpae	1) Topkapi - Ribasim chain, implemented in the Drought Early Warning System of Emilia-Romagna region 2) River basin district Authority		1) Modflow model to describe groundwater flow in Reno RB 2) Arpae

	RCP4.5 emission scenario; 2) Arpae							
Spain - Jucar RB	?? CMIP6 climate projections on SSP1_2-6, SSP3_7.0 and SSP5_8.5 downscaled and bias adjusted against ERA5-Land. Additional scenarios and experiments (e.g. CORDEX) might be used depending on their usefulness	1. Aquacrop model 2. PUV, Júcar Basin Authority	1. TETIS model	1. For standard water quantity simulation: Aquatool or GAMS model. For hydroeconomic simulation and optimization (stochastic and deterministic): GAMS model 2. PUV?	1. The hydroeconomic Water Resource System model is a microeconomic system model as well 2. PUV?		1. Projections on relevant socio-economic variables will be obtained from the IMAGE model or similar 2. ?	
Slovakia - Nitra RB	EURO-CORDEX´s RCMs and RCP2.6, 4.5, and 8.5, ERA-interim reanalysis. SHMÚ is also working on projections using their model ALARO_1 governed by the CNRM_CM6(ESM2-1) emissions	Drought dynamics analyses based on the SPEI. Climate water balance CWB (Technical University Zvolen) Drought monitoring based on water balance model SoilClim model combined with long-term reference and remote sensing (SHMÚ) - no information how widely it's being used by agronomists		Hydrus 2D and GLOBAL model for soil hydrology (Technical University Zvolen) 1D, 2D models for runoff (Slovak	MIKE, HBV, HecRas (1D, 2D, SHMÚ, SVP) SWAT (in some pilot studies, Slovak Academy of Sciences)	No hydroeconomic model available in the lab	No hydroeconomic model available in the lab	State Geological Institute of Dyoníz Štúr - hydrological analysis an modeling of groundwater movement

	scenarios SSP126, SSP245, and SSP585, 4 x 4 km or even 1 x 1 km. This is still work in progress (SHMÚ). CCSM- CMIP5 and RCPs 4.5-8.5 (Technical University Zvolen)		Academy of Sciences) 1D, 2D hydrodynamics modelling	Climatic Water Balance (CWB) automated warnings (Technical University Zvolen)			
Greece - Tympaki RB	Climatic models GCMs such as ECHAM5, IPSL, CNRM and CMIP5 EURO-CORDEX RCMs (CCLM4-8-17, HIRHAM5, RAMCO22, RCA4) downscaled for Crete - Scenarios RCP 4.5, RCP 8.5	1.Hydrus 2d/3d model 2. Aquacrop model These models are managed by ELGO-DIMITRA	1. SACRAMENTO model 2. SWAT model 3. HSPF model 4. MODFLOW and SEAWAT models Sacramento, Modflow and SWEAWAT are managed by the Region Crete and the Technical University of Crete. SWAT and HSPF are managed by ELGO-DIMITRA	1. RIBASIM model (managed by the Region of Crete) 2. MIKE SHE model (managed by ELGO-DIMITRA)			1. DEFICIT open access platform for irrigation needs (per parcel) (managed by ELGO-DIMITRA)

Peru, Bolivia & Chile - Caplina-Mauri-Desaguadero System	HadGEM2-ES / WRF [SENAMHI Peru] HadGEM2-ES / ETA [CORDEX] HadGEM2-ES / REMO 2015 [CORDEX] MPI-ESM-LR / REMO 2015 [CORDEX] HadGEM2-ES / RCA4 [CORDEX] MPI-ESM-LR / RCA4 [CORDEX], [The models area available for RCP 4.5 and 8.5	Estimations of agronomic systems using Penman Monteith method adapted from FAO 56.	Soil Moisture method in WEAP	~~1.~~ WEAP. For planning and management objectives in local and regional level.	No hydro economic model for the lab	No hydro economic model for the lab	
India - Mahanadi RB			Rainfall-runoff modelling	Water Evaluation and Planning System			Analysis of groundwater levels-long term and seasonal trends for several observation wells

Lebanon, Syria & Turkey - Orontes RB	CMIP6 climate projections on SSP5_8.5; NASA Earth Exchange Global daily downscaled climate projections AUB	Aquacrop - MoEW	WMS, HMS AUB	WEAP - AUB	TBA	TBA	

2.2.3. Stakeholder competences – focus on data

Please list 1) the data sources used to populate the system models identified in the previous section for your lab, including <u>input data for models and scenarios and other forcings (e.g., climate change scenarios)</u>; and 2) the stakeholders responsible of managing this data (only the stakeholder name – a more detailed narrative of each stakeholder is required in Section 2.2.4). If a data input is used in more than one system, list them in all relevant systems.

LAB	Climate system	Agronomic System	Hydrological System	Water Resource System	Microeconomic System	Macroeconomic System	Other relevant systems
Italy - Reno RB	1a) observed data over Reno Basin from ERACLITO database: source https://dati.arpae.it/dataset/erg5-eraclito 1b) observed large scale data from ECMWF reanalysis: source https://apps.ecmwf.int/archive-catalogue/ 1c) simulated large scale data from CMIP5 experiment: source Copernicus Climate Data Store : source (https://cds.climate.copernicus.eu/cdsapp#!/dataset/projections-cmip5-monthly-single-levels?tab=form 2) Arpae	1a) pedological, agricultural and meteorological data) 1b) meteorological data, pedological data and groundwater data 2a) Arpae	1a) hydrological data, meteorological data, meteorological modeling data 1b) hydrological data, meteorological data, meteorological modeling data 2) Arpae	1) hydrological data, meteorological data, meteorological modeling data 2) River basin district Authority			1) groundwater data 2) Arpae

		2b) Canale Emiliano Romagnolo for IRRINET irrigation system					
Spain - Jucar RB	1. The primary projections will be CMIP6 climate projections on SSP1_2-6, SSP3_7.0 and SSP5_8.5 downscaled and bias adjusted against ERA5-Land. Additional scenarios and experiments (e.g. CORDEX) might be used depending on their usesfulness 2. CMIP6	?	?	?	?	?	?
Slovakia - Nitra RB	SHMÚ: The models were fed regional meteorological data from the EOBS. The reference period for ERA-interim reanalysis was 1961-1990, resp. 1981-2010. (Technical University Zvolen): Continuous meteorological measuring via AMS stations provided by Technical University in Zvolen located in: Prievidza Púšť (388 m a.s.l.),Prievidza city (291 m a.s.l.)	Continuous automated measuring of trunk increment and SapFlow dynamics on fruit trees in orchards Continuous measuring the soil water potential in the open reference locality and forests in the	Climatological data (meteorological stations), hydrological and partial hydrobiological data including data on heavy metals concentrations, data on the quality of surface waters, quality and quantity of groundwaters	In-situ measurements at AMS stations Climatological and hydrological data from the national monitoring stations (SHMÚ).	NA	Statistical office of the Slovak Republic, The Geodesy, Cartography and Cadastre Authority of the Slovak Republic	Quantitative and qualitative data on groundwaters available at State Geological Institute of Dyoníz Štúr

		water basin. In forests are also measured tree trunk increment dynamics on an hourly basis.		Water quality data (WRI, SVP) Water quantity data (SHMÚ, WRI, SVP, Water distribution companies)			
Greece - Tympaki RB	1. Meteorological data from stations in Crete of the National Observatory of Athens (NOA) and the Decentralised Administarion of Crete 2. E-OBS v19.0 gridded dataset 3. EURO-CORDEX RCMs (CCLM4-8-17, HIRHAM5, RAMCO22, RCA4) downscaled for Crete 4. Extreme Sea Level (ESL) dataset from the JRC programme LISCOAST (Large Scale Integrated Sea-level and Coastal Assessment Tool)	1. Meteorological data from stations in Crete of the National Observatory of Athens (NOA) and the Decentralised Administration of Crete	- Hydrometeorological data (timeseries) of daily precipitation, evapotranspiration, streamflow, spring discharge - Groundwater levels from monitoring wells, and groundwater abstraction and pumping rates - Aquifer characteristics/properties,	- Population data per administrative unit - Water use data (calculated from proxies and from water meters) - Data from the water use licenses on the location of wells and	Water tariffs (from TOEV for irrigation, and from DEYAR for municipal water supply)	ELSTAT data	DEFICIT open access platform for irrigation needs (per parcel)

			groundwater recharge zones - Reservoir characteristics and operational rules - Land use (data and shapefiles), irrigated areas, crop mix and relevant crop parameters Data are available for the Region of Crete and the WDC	the specific amount/volume of water to be abstracted and used within specific time (usually 10 yrs) - Schematic representation of the basin and GIS shapefiles (hydrological network, sub-catchments, dams and reservoirs, groundwater bodies, water demand nodes for various			

				users, water canals, irrigation works, irrigation methods, abstraction points, transmission and return flow links, flow requirements, losses) - Water quality data from monitoring stations, chemical and ecological status classification of the water bodies			

				- Delineation of nitrates vulnerable zones - Delineation of flood risk zones Ancillary information available within the WFD RPMP and the FRMP Data are available for the Region of Crete and the WDC			
Peru, Bolivia & Chile - Caplina-Mauri-Desagua	Escenarios Climáticos en el Sistema Hídrico del lago Titicaca, Río Desaguadero, Lago Poopó y Salar de Coipasa [GEF, PNUD]	Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). Crop evapotranspiration-	[Yates, D., Sieber, J., Purkey, D., & Huber-Lee, A. (2005). WEAP21—A demand-, priority-, and preference-driven	[Yates, D., Sieber, J., Purkey, D., & Huber-Lee, A. (2005). WEAP21—	No hydro economic model for the lab	No hydro economic model for the lab	

dero System		Guidelines for computing crop water requirements-FAO Irrigation and drainage paper 56. Fao, Rome, 300(9), D05109.	water planning model: part 1: model characteristics. Water international, 30(4), 487-500.]	A demand-, priority-, and preference-driven water planning model: part 1: model characteristics. Water international, 30(4), 487-500.]			
India - Mahanadi RB	Meteorological data (especially rainfall data) maintained by the Indian Meteorological Department (IMD) for several gauging stations; hydrological data maintained by the Central Water Commission; groundwater level data available for several observation wells from the Central Ground Water Board; Water quality data for selected stations in Mahanadi river from Central Pollution Control Board		Gauging data of the rivers from CWC;	Technical data available from the State Water Resources Department (storage-area elevation curves of major & medium reservoirs; reservoir mass	No. of different types of industries; water consumption by industries; human & livestock population; size of urban population		Groundwater level data from the Central Ground Water Board (CGWB)

				balance data			
Lebanon, Syria & Turkey - Orontes RB	CMIP6 climate projections on SSP5_8.5; NASA Earth Exchange Global daily downscaled climate projections AUB	Gauge + flow data + simulated river flow data LRA, MoEW	WMS, HMS AUB	WEAP - AUB			

2.2.4. Stakeholder competences – detailed assessment

Describe the main stakeholders and their competences, providing a narrative. It is recommended that the capacities assessment is based on qualitative statement, such as 1- developing, 2- proficient, 3- accomplished, related to stakeholders' capacities. Put each stakeholder in one separate paragraph. One stakeholder may appear in more than one section – in that case, only include the relevant competences for that section.

2.2.4.1. What stakeholders collect data and monitor enforcement of water management decisions?

This includes stakeholders who collect and analyze data related to water quantity and quality, as well as those who ensure that water management decisions are being enforced. These stakeholders may include users, government agencies, water utilities, or community-based organizations (municipalities). Identify 1) key competences (including models), 2) participation in various water management processes, 3) grade their qualitative and quantitative capacities (1- developing, 2- proficient, 3- accomplished) and 4) identify key data gaps (build on your answer in Section 2.2.2).

2.2.4.1.1. Júcar River Basin (Spain)

Jucar Basin Agency (CHJ)	Achieve a sustainable water use, fulfil the WFD, reconcile all the water users and interests, ensure that dams are adequately operated
Jucar Users Union (USUJ)	Downstream farmers with elder rights and Iberdrola. Want to ensure the sustainability of their activities and preserve the elder-right position they currently hold. Legal owners of the main reservoir (Alarcon).
Acequia Real Del Júcar (ARJ)	The most important farmer association among USUJ members. Want to ensure the sustainability of their farming activities and preserve the elder rights that they currently hold.
Canal Jucar-Turia (CJT)	Farmers without elder rights from the lower Jucar. They use surface and ground water, during droughts they are not allowed to use surface water unless they pay a financial compensation to USUJ. They want to ensure the sustainability of their farming activities and achieve a more equitable share of surface water
Junta Central de Regantes de la Mancha Oriental (JCRMO)	Farmers without Elder rights from the middle Jucar. They use mostly groundwater, although lately they have been entitled to a small share of surface water. Due to the overexploitation of the aquifer from which they pump (Mancha Oriental) they are being pushed to reduce their pumping rates. They want to ensure the sustainability of their farming activities, stop or at least reduce the pace of groundwater pumping curtailments and increase the share of surface water they currently have
Iberdrola (energy company responsible of hydropower production)	Member of USUJ and the owner of all the main hydropower facilities in the basin. They also own the hydropower reservoirs in the middle Jucar, which can be freely operated subject to some restrictions on their minimum and maximum storage levels, as well as environmental flows. They want to preserve the *statu-quo* in terms of managing their own reservoirs

City of Valencia	75% of the water used by Valencia comes from the Jucar. Urban supply has priority over agriculture according to the Spanish law, so they do not expect curtailments. However, an expansion of their current share to cope with population increase is unclear. They are also worried about water quality issues.
City of Albacete	It used ground water until they switched to surface water due to quality issues. During droughts it has to pay a financial compensation to USUJ. It would like to preserve and expand its surface use and avoid as much as possible the payment of financial compensations
Government of the Valencian Region	The Jucar water supplies water to the main urban area of the region, some of the main farming sectors and the most known protected are in the region. It wants to preserve and improve if possible the economic activity of the farming districts and the ecological status of the protected areas.
Government of Castille – La Mancha	It would like to increase the share of the surface water of the Jucar, which is currently allocated mostly to the lower basin, as surface water is cheaper and cleaner than the ground water from the Mancha Oriental aquifer
Xúqer Viu (environmental NGO)	Platform made up of several environmental NGOs, municipalities and other public and private entities. They would like to improve the environmental status of the river, in particularly increasing the minimum environmental flows and preventing water transfers from the Jucar to other basins (e.g. the Jucar – Vinalopó transfer)
AEMS Ríos con Vida (environmental NGO)	Nationwide NGO founded by fishermen pursuing a sustainable fish population and fishing activity. They would like to improve the environmental status of the Jucar to enable a healthy habitat in its streams, favouring native species.

2.2.4.1.2. Nitra River Basin (Slovakia)

Slovak HydroMeteorological Institute (SHMÚ) is responsible for hydrological and climatological monitoring in the national monitoring network. SHMÚ monitors hydrological variables such as water level, flow, water temperature, ice events, water clarity, hydromorphology (in natural water courses) continuously. SHMÚ also assesses trends and prepares prognoses of water quantity and regime and issues warnings for flood risk. In addition, the institute is responsible for analyzing data from monitoring and compiling annual reports on the water balance and quality of the surface waters in coordination with other institutes, as well as annual report on water quality for the ICPDR. The data are also forwarded to OECD, EEA, GRDC and ICPDR (International Commission for Protection of the Danube River). They use ensemble models for projecting mean annual, seasonal, monthly air temperature for 2021-2050 and 2071-2100. Daily precipitation, RH, wind speed, PWP, global radiation and based on that also heatwaves, heavy rainfalls and intensiyt of heavy rainfalls were modelled.

SVP is partly responsible for monitoring the quality of surface waters in terms of physical, chemical, biological, and microbiological properties. SVP also contributes to the annual reports prepared by the SHMÚ on the water quality. SVP is also working towards flood protection and developed a GIS online support tool where the areas subject to flood risks can be seen.

The Water Research Institute (WRI) monitors hydromorphology of water courses that are at risk and significantly altered (while SHMÚ monitors the natural water courses). WRI is responsible for assessing the ecological and chemical status of surface waters on a 6-yr basis for the purposes of updating the Water Plan of the Slovak republic and river basins water management plans. Beside that, WRI monitors radiological indicators. WRI is also in charge of preparing various reports required by directives of the EU (e.g. EEA´s core set of indicators).

SAŽP is mainly responsible for compiling of data, reporting under the directives´ obligation to the EC and EEA
All the data and reports are provided for the Ministry of Environment, other water authorities, Statistical office of the Slovak republic, and others.

Water Patrol established by the state water authority on behalf of the water manager, owner of a waterwork, or by towns control compliance to the Water Act and report to the water authority in case the water user is not following the law. In such case, water patrol reports to the water authority (usually the district authority) who processes the case. The water authority may then decide to terminate the water permit in case one was granted to the user who broke the rules.

Slovak Environmental Inspectorate (SEI) is the main controlling body overseeing the compliance with the Water Act. It sees that the water manager (SVP) decisions in regards to water use and management are followed. This includes controlling the waste water treatment and release, protection of the water, etc.

Ministry of Agriculture and Rural Development is in charge of assigning water sources that can be allocated for irrigation and defining the rules for irrigation water.

State Nature Conservancy (ŠOP SR) is the agency of the Ministry of Environment responsible for the protected areas, including wetlands, rivers, lakes, forests within these areas.

2.2.4.1.3. Reno River Basin (Italy)

Po River Basin District Authority. Reno falls within the Po River basin district and the competence area of the **Po River Basin District Authority** (AdbPo) responsible for managing the maintenance of the Po river and its tributaries. Established in 1989, the AdbPO is responsible for the maintenance of the Po River and its tributaries. In 2016, it was reorganized as part of a new system of basin district authorities. AdbPo is responsible for planning and implementing river basin management plans, monitoring water quality and quantity, managing hydraulic works and infrastructures, promoting sustainable agricultural practices, and coordinating emergency responses to flood and drought events. It works to ensure the sustainable use of water resources, prevent and mitigate flood and hydrogeological risks, and promote the ecological and landscape values of the river basin. **Inter-regional agency for River Po** (Agenzia Interregionale per il fiume Po, AIPO) is an inter-regional agency established in 2003 and its main objectives are the hydraulic safety of the territory of the Po basin and the construction and management of works for river navigation.

The **Emilia-Romagna Regional Authority** oversees the implementation of water policies and coordinates with local authorities and stakeholders to manage water resources effectively. The Department for soil protection, coast and land reclamation is responsible for ensuring adequate levels of hydraulic and hydrogeological security. Its main goal is to reduce risks to safeguard the environment and landscape. This is achieved through planning the use of the territory and programming interventions to defend the soil, coast, and reclamation. The Department collaborates with Basin Authorities to form basin plans and is also responsible for drafting laws, regulations, guidance, and control acts for delegated matters. The Department of water protection and management collaborates with Basin Authorities to form basin plans and it is responsible for analysis, planning, management and monitoring activities of policies for water resources and environment sustainable management for the regional territory. It drafts laws and regulations on water resources use and water discharge, it coordinates delegated institutions and territorial services and it promotes initiatives about communication, awareness and dissemination on water use and consumption. The region is also supported by the **Sector of territorial security and civil protection of the Reno district** (Settore sicurezza territoriale e protezione civile distretto Reno).

ARPAE is the Regional Agency for Prevention, Environment and Energy of Emilia-Romagna (Arpae), and has the mission of "ensuring authorizations and concessions, monitoring, control and environmental prevention to promote sustainability, health protection, territorial safety and the enhancement of resources and environmental knowledge".

The Reno Basin RLB (Consorzio della Bonifica Renana) is a public body that reunites every building or landowner in the Reno basin area. Its main services are: drainage and maintenance activities in plain areas; water allocation for agriculture (62% from Po river, 8% from Reno river and 30% from other sources); hydrogeological protection in mountain and hill areas; agricultural activities and environmental protection; dissemination activities.

The private Consortium of Casalecchio Lock and Reno Canal (Consorzio della Chiusa di Casalecchio e del Canale di Reno**)** coordinates the allocation of water resources deriving from Reno river through several canals of the city of Bologna, mainly for industrial use (hydroelectric plants, heat exchangers), but also for environmental and irrigation use. The municipalities interested by this consortium are Casalecchio di Reno, Bologna and Castel Maggiore, characterized by a high degree of urbanization.
The regional agency for territorial security and civil protection (Protezione Civile) manages several territory prevention and protection activities including hydraulic risk. In this context, its main roles are: securing of waterways through structural and repair actions, and river flood service.

ATERSIR is the Agency for the regulation of local environmental public services of the Emilia-Romagna Region, which also deals with Integrated Water Service (aqueduct, sewerage and purification), and **HERA** is a joint-stock company and operator of potable water sources for the Reno basin.

2.2.4.1.4. Tympaki River Basin (Greece)

The Region of Crete, with a direct interest in the protection and management of water resources. As the Region of Crete bears the responsibility for the design and construction of infrastructure/ water works (dams, wells, water supply and distribution systems) it has a high influence on the overall water supply and allocation. It is also responsible for the design and implementation of measures, such as water use restrictions among others. Finally the Region of Crete is responsible for pollution monitoring and environmental protection (e.g. ecological flows, good water quality status, etc.), as well as for the development of the Regional Agricultural Development Plan. As such they collect data necessary for the design and operation of the water works (hydrometeorological, reservoir data including operational data, water quantity, major abstraction points), data to monitor the implementation of measures (including on-site inspections), as well as data on water quality, pollution and environmental status. They also collect land use data. Capacity level: 3- accomplished.

The Water Directorate of Crete Decentralized Administration (WDC), with a direct interest in the proper implementation of the WFD River Basin Management Plans (RBMPs) and related Programme of Measures. As the WDC bears the responsibility for issuing the water use licenses it has a high influence on controlling groundwater abstraction and overexploitation. They are responsible for running the national WFD monitoring network and collecting data on water quality and ecological status. They also have records of all licensed groundwater abstractions and monitor/enforce if the licenses' rules are respected. Capacity level: 3- accomplished.

The Local Land Reclamation Organization (TOEV of Zone A' of Messara) hasa direct interest on efficiently meeting irrigation water demand. This organization (TOEV) bears the responsibility of providing sufficient irrigation water to the farmers, as well as adequately operating and maintaining the irrigation water supply and distribution systems, and collection of water fees. As such they monitor the levels and abstraction rates of the TOEV pump stations and local reservoirs of their distribution system, the monitor leakage, they collect data from the farmers' water meters (i.e. water use for irrigation) and they have registers of the water tariffs and bills that they collect from the farmers. Capacity level: 2- proficient.

The Municipal Water Supply and Sewerage Company of Faistos (DEYA Faistos) bears the responsibility to collect and treat domestic wastewater. They collect domestic water use data from the users' water meters (i.e. domestic water use), they have registers of water tariffs and bills, and they also hold data related to the operation of their wastewater treatment plan. Capacity level: 2- proficient.

The Hellenic Survey of Geology & Mineral Exploration (EAGME) is responsible for the monitoring system of the groundwater, and thus they monitor groundwater levels and quality in observation wells. Capacity level: 3- accomplished.

The Technical University of Crete (TUC) collects ad-hoc data for research purposes. These data are mainly hydrometeorological data. Capacity level: 3- accomplished.

2.2.4.1.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

In the binational region of Caplina-Mauri-Desaguadero, there are three entities which collect data from a monitoring network of stations to check climate and hydrology. The National Service of Climate and Hydrology [SENAMHI] from Peru collect data related to climate and hydrology around Puno, and Tacna provinces [Caplina, Locumba, Maure basins], in the same way SENAMHI from Bolivia collect data of climate and hydrology in La Paz and Oruro provinces [Mauri, Desaguadero basins]. Last information related to diverted flows are monitored by the Proyecto Especial Tacna [PET] from Tacna which has a network from Tacna to Puno [Caplina, Locumba, Sama and Maure basins]. Information in the area is available since 1960 to the present, with some meteorological and hydrological stations out of work due to maintenance issues.

ALT which is the entity with binational jurisdiction has faced difficulties in fulfilling its mandate due to political, institutional, and financial constraints. In recent years, there have been efforts to revitalize the ALT and strengthen its role as a platform for dialogue and cooperation among different stakeholders at local, national, and regional levels. The BRIDGE project (Building River Dialogue and Governance) has been working since 2011 to support this process by providing technical assistance, capacity building, knowledge sharing, and procedural advice to the ALT and other actors involved in the basin. The project aims to promote water diplomacy and governance based on equitable economic, environmental, and social benefits for all. The BRIDGE project also uses a combination of knowledge and information tools, capacity building and training, and dialogue facilitation to strengthen relations between stakeholders across local, provincial, national, and regional levels. The BRIDGE project has supported the development of a joint diagnostic study, a transboundary water resources management plan, and a Binational Commission for the Maure-Mauri basin which up to now is working under the supervision of both ministries of foreign affairs from Bolivia and Peru.

Finally, the Ministerio de Medio Ambiente y Agua (MMAyA) of Bolivia and the Ministerio del Ambiente (MINAM) of Peru, which are the national authorities in charge of environmental and water policies; and various public sector entities, civil society organizations, academic institutions, private companies, and local communities that participate in the data collection, analysis, and validation processes. Additionally, in the case of Peru there is a water authority called National Authority of Water [ANA] which has local secretaries to enforce the application of the law of water resources for almost 13 years since 2010, which has a water management plans for the Pacific and Maure [Titicaca] regions. Both countries considering the complexity of the transboundary region of Maure – Mauri decided to create a Technical Binational committee to build a specific water management plan for this basin in particular, this effort has been done since 2006.

2.2.4.1.6. Mahanadi River Basin (India)

Though the water resources department has powers to allocate water from the reservoir and diversion schemes which it builds as per the allocation plans worked out at the time of planning of the scheme, during emergencies, the district collector has powers to freeze such reservoirs and earmark the water for high priority, basic survival needs. Such allocations are not based on serious considerations of the socio-economic realities, but instead are knee jerk reactions to an imminent crisis. Often when water from reservoirs is frozen, on Collector orders, it remains in these reservoirs, due to lack of adequate infrastructure for transporting to the place experiencing severe water shortages. While such decisions result in reduced allocation of water for irrigation, no rules exist and no mechanisms are in place for compensating for the farmers who are adversely affected.

The absence of an apex agency for water resource governance at the state level is conspicuous, like in many other states, as many conflicts emerge over allocation of water across sectors. Such an agency can be responsible for framing rules relating to: i] the resource evaluation and planning methodology, planning units, tools, processes and agencies to be employed for resource evaluation and planning; ii] the degree development of water resources, the potential sources of financing of water projects, the agencies which can execute water resource development projects, and agencies which can manage them; iii] the allocation of water from public systems to various sectors and the price that should be charged for water supplied to each sector; and, iv] the various considerations (criteria) used for framing such rules.

Framing of rules regarding the proportional allocation of water from a river basin to different sectors, including the environment itself is a major governance challenge. Good governance calls for using social, economic and environmental considerations in framing water allocation rules. This is crucial for reducing future conflicts. However, currently, such allocations are largely driven by political interests.

An equally difficult challenge is to evolve rules regarding the pricing of water in different sectors. There is no consensus on whether prices should be on the basis of the cost of production of water, or the affordability of water for the user communities, or the economic benefits produced by the use of water in a particular sector. The ideal pricing norm should be based on all these considerations. This means that in sectors such as industry, wherein water use efficiency (Rs/m3 of water) or the economic return from the use of unit volume of water is generally very high, the unit price of water could be much higher than that in irrigated agriculture, which has relatively much lower water use efficiency, owing to the higher ability to pay. In the case of basic survival needs such as drinking & domestic water supply, since the social benefits of consuming adequate quantities of water (in the form of preventing malnutrition, lower infant mortality and lower incidence of water borne diseases resulting in better human development) are high, subsidies will have to be provided to those who are poor to make water supply services affordable.

However, in the case of water sharing between Chhattisgarh and Odisha, the Central Water Commission is currently monitoring any further development of surface water resources in Chhattisgarh part of the basin and water releases from Hirakud reservoir for the lower riparian state of Odisha. A gauge and discharge sites had been opened at the inter-state border of Odisha and Chhattisgarh at a location, for effective measurement of flows from Chhattisgarh catchment into Hirakud dam.

2.2.4.1.7. Murray-Darling Basin (Australia)

MDBA: the Basin Authority maintains the modelling for Basin water management purposes and retains mostly functions of river operations and trade regulation. They set the priorities annually for environmental targets and objectives in conjunction with DCCEEW. MDBA also focuses on water quality with respect to salinity management and reduction across the entire Basin, with a key focus though in southern parts. River monitoring using gauges, flow meters and storage operations are also an MDBA role along with environmental monitoring and evaluation/reporting on key ecological achievements via The Living Murray program. Finally, the MDBA are responsible for coordinating the joint agreement between the state and federal governments/departments and management of the Basin Plan and reporting on various outcomes under that regulatory framework. The Authority delivers an Annual Report each year that contains a lot of this information, as well as a range of communications within a year. Capacity for the MDBA would be set at accomplished, but on a downward trend in recent years.

DCCEEW: includes both the CEWH and CEWO divisions, and the separate water trade division attached to the Department (using Chinese Wall principles) to improve and bolster national environmental water holdings for ecological benefits (i.e., buying/selling water each year in line with environmental targets and best achieving them in locations across the Basin). DCCEEW are also tasked with delivering prioritized environmental watering objectives each year on conjunction with MDBA, and for monitoring and reporting to various state/federal agencies on progress. They are also responsible for the water recovery program across the MDB which has had a focus on direct buyback from willing irrigation sellers and subsidized investment in water efficiency projects at farm, IIO and larger system (e.g. state water projects) levels. Buyback was generally ruled out of general use after a Parliamentary Review (Australian Parliament, 2011), while in more recent years Ministerial support for water efficiency has also waned leading to that recovery prospect also diminishing in relevance (Pérez-Blanco et al., 2021). Water recovery, which is incomplete, thus remains at an impasses for now. DCCEEW capacity would be ranked as accomplished.

IGWC: a new compliance organization devolved from the MDBA's original role in this space. Stopped the MDBA from essentially 'marking their own homework' and increased perceptions of accountability and compliance in the water arena. As a new organization capacity still set as developing, as are their roles, reporting outcomes, key tasks and final responsibility/effectiveness.

2.2.4.1.8. Orontes River Basin (Lebanon)

Lebanese Government and Parliament: Parliament and the government are responsible for passing draft laws, implementation decrees and budget allocations to ministries. Ministries oversee water use and water security policies are tasked with setting and implementing regulations on licensing water use and water quality. Ministries are responsible for regulations and enforcement. Policy making, master planning, and implementation are the responsibility of the Ministry of Energy and Water, and the Council for Development and Reconstruction.

Within the water sector, the Ministry of Energy and Water in Lebanon has specific powers and duties. These include establishing necessary policies, regulations, strategies, and decrees, as well as overseeing and monitoring Regional Water Establishments (RWEs) and Local River Authorities (LRAs). The ministry is also responsible for licensing wells and regulating all water extractions. It manages the national allocation and distribution of surface and groundwater for drinking and irrigation purposes. Additionally, the ministry continuously updates and drafts general directives for water and sanitation while maintaining control over the quality of surface water and groundwater.

Council for Development and Reconstruction (CDR): Account to the prime minister, assess infrastructural needs arising from the civil war and allocate funding for reconstruction. It is the primary channel for overseas funding of water investment.

The Litani River Authority (LRA): implementing the Litani irrigation, drinking water and electricity projects, establishing a network to link power stations in Lebanon, establishing electrical substations and distribution lines in all regions, and investing in the different parts of the projects at both the technical and administrative levels. Other functions include water monitoring of all rivers in Lebanon; managing irrigation projects in central and northern Bekaa; conducting studies related to diverting water on tributaries of the Jordan River Basin, mountain lakes in the northern and Mount Lebanon areas; and conducting studies on the construction of the Bisri Dam on the Awali River.

Regional Water Establishments (RWEs): they are public corporations, legally responsible for operation, maintenance and fee collection in water, wastewater and irrigation services. The Bekaa Water Establishment (BWE) was established to oversee the water sector in Lebanon's Bekaa and Baalbek-

Hermel Governorates. Its responsibilities include studying, constructing, operating, maintaining, and upgrading water projects for potable and irrigation water distribution. The BWE is also tasked with collecting, treating, and disposing of wastewater in accordance with the master plan or the Ministry of Environment's approval. Additionally, it suggests tariffs for water services and monitors the quality of distributed water and treated wastewater.

Municipalities: manage individual water supply and wastewater schemes. They have the formal ability to aggravate or block any project via granting construction permits.

2.2.4.2. What stakeholders conduct climate and hydrological modelling?

Identify stakeholders who have expertise in climate and hydrological modelling and are crucial for understanding the impacts of climate change on water resources. These stakeholders may include academic institutions, hydrological or climate services, and other government agencies. Identify 1) key competences (including models), 2) participation in various water management processes, 3) grade their qualitative and quantitative capacities (1- developing, 2- proficient, 3- accomplished), 4) identify existing modelling gaps (e.g., insufficient interaction with socioeconomic models) (build on your answer to Section 2.2.3).

2.2.4.2.1. Júcar River Basin (Spain)

The water authority in the basin (CHJ) has included an annex dedicated to climate change risks and adaptation in the last planification cycle. The annex takes information from the ICCP, and additional more refined data produced by the Centro de Estudios y Experimentación de Obras Públicas (CEDEX) to estimate the impact of climate change on the territory.

This study tries to quantify the impacts due to climate change on water resources, the associated ecosystems and the satisfaction of demands. Their estimation is based on the latest available climate projections, focusing on the effect of climate change on temperature, rainfall and all the components of the hydrological cycle. Thus, the expected decrease in surface and groundwater resources and the changes in the incidence of extreme events: droughts and floods are taken into account. Based on these changes, the affectation to the fluvial ecosystems due to the change in water temperature (fish species, macroinvertebrates and dissolved O2) is also considered. Additionally, other environmental aspects where the adaptation plan should focus are identified, such as desertification processes in the catchments and the evolution of invasive species. The expected effects on the Mediterranean coast have been presented and how sea level rise can affect coastal wetlands, especially l'Albufera, the most emblematic wetland in the region. Finally, the results of the annex on use and demands have been presented, both in deficit and compliance with guarantees for agricultural and urban uses, as well as losses of hydroelectric production and guarantee in cooling of the Cofrentes Nuclear Power Plant, under climate change conditions.

2.2.4.2.2. Nitra River Basin (Slovakia)

SHMÚ, as an institution under the Ministry of Environment, is responsible for collection and analysis of climatological and hydrological data. Addressing the objectives of National Adaptation Plan, SHMÚ is currently working on preparing updated climate scenarios for 2030/2050 and on estimating the impacts of climate change on the various sectors, which are supposed to be finalized in 2023. Some of the analyses have been presented, however, little work is published or otherwise available.

2.2.4.2.3. Reno River Basin (Italy)

The Climate Observatory of Arpae Emilia-Romagna conducts climate modeling providing seasonal climate projections at regional and macroarea level. The projections are built through the statistical downscaling scheme based on Perfect Prog approach. Large-scale fields data simulated by different global climate models (GCMs) from CMIP5 experiment, in the framework of RCP4.5 emission scenario, will feed the statistical downscaling scheme in order to produce future projections of precipitation over Reno basin. An Ensemble Mean technique will be applied in order to reduce uncertainties and give more statistical robustness of the results.

The Hydrology Branchof Arpae Emilia-Romagna conducts hydrological modeling through two systems:

1) Flood Early Warning System (FEWS) is a multi-model approach based on three rainfall-runoff modeling chains (Mike 11-NAM, HEC-HMS, Topkapi) and a hydraulic model for flood forecasts; these models are based on hydrometeorological observed data and hydrometeorological products.
2) Drought Early Warning System (DEWS) is based on the model chain Topkapi-Ribasin, based itself on hydrometeorological observed data and hydrometeorological products.

The University of Bologna (Department of Civil, Chemical, Environmental, and Materials Engineering) conducts research on hydrological rainfall-runoff modeling.

The University of Parma (Department of Engineering and Architecture) conducts research on groundwater, hydraulic and hydrology model calibration.

2.2.4.2.4. Tympaki River Basin (Greece)

The Region of Crete has expertise (2-proficient) in hydrological modeling and they currently have the following models:

<u>RIBASIM model</u>: This is a water management/water allocation model and has been used for high level basin planning as a Decision Support System (DSS). It allows for the estimation of water demands under different scenarios that have been incorporated in the modes, for distributed water resource allocation (demand nodes-based) where prioritisation is user-defined (within water districts and on distribution network level), as well as for impact analysis (WADIS module: crop production, costs and yields; DELWAQ module: water quality modeling, flow composition on distribution network level). The spatial resolution of the mode is per node and aggregated per catchment, while it runs at a monthly timestep. The following output parameters are provided by the model:

- Per water use/demand node: available water (m^3/s), water demand (m^3/s), ratio (%) of water availability/demand, flow to downstream (m^3/s), water deficit, % of time with water deficit

- Per hydrological node: storage capacity (Mcm), water level (m), produced and consumed energy (GWh), filling rate (%), available surface and groundwater (m^3/s), streamflow (m^3/s), downstream flow (m^3/s), total surface water availability and demand (m^3/s), total groundwater availability and demand (m^3/s), return flow (m^3/s), groundwater storage (Mcm)
- Per environmental requirement node: % requirement met.

The existing RIBASIM model presents a couple of shortcomings. As it has been developed for the entire island of Crete, it may require further discretization and disaggregation to capture more detailed specificities of the Tympaki basin. It also needs to be updated and run for the most recent years, and to incorporate new and updated scenarios on future climate and socio-economic changes. Specific side elements could also be improved, like the surface-groundwater interaction and the definition of environmental flows.

<u>SACRAMENTO model</u>: This is a continuous rainfall-runoff model used to generate daily stream flow from daily rainfall and potential evapotranspiration data. It uses soil moisture accounting to simulate the water balance within the catchment (i.e. functional unit). The input data are from existing monitoring stations. The model is run at catchment spatial scale and daily timestep. The following output parameters are provided by the model: daily surface and base flow (m^3/sec), soil moisture depletion by evapotranspiration and soil moisture redistribution, soil moisture replenishment by rainfall and percolation. The existing model needs to be updated and run for the most recent years and also run against future climate change scenarios (altered precipitation and ET patterns).

<u>MODFLOW model</u>: This is a groundwater model simulating and predicting groundwater conditions and groundwater/surface-water interactions. The model is grid-based including the different aquifers, and runs at an annual timestep. The existing model needs to be updated and run for the most recent years and could also benefit from a monthly temporal resolution.

The ELGO-DIMITRA has expertise (3-accomplished) in hydrological modeling and they currently have the following models: SWAT model, MIKE SHE model, HSPF model.

That Technical University of Crete (TUC) has expertise (3-accomplished) in hydrological modeling and they currently have the following models: MODFLOW, FEFLOW, KARST SWAT.

The National Observatory of Athens (NOA) has expertise (3-accomplished) in climate modeling and has provided input in the development of the Regional Plan for Adaptation to Climate change in Crete (PESPKA).

2.2.4.2.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

In Peru the entities working with hydrological models are ANA and SENAMHI. In the case of ANA, they use the models for water distribution and control of licenses with its local water authorities in each region. SENMAHI has several models to feed the studies at climate and hydrological level, not only for national but for specific basins which required special studies such as the case of the Maure River basin due to presence of volcanic activities and the presence of transboundary aquifers in the region of Ayro in Uchusuma region in Puno.

In Bolivia, SENAMHI works with models to simulate the hydrology of the basin in all the country. In the case of the region of Mauri and Desaguadero River basins they have specific studies with some models developed to represent the climate to evaluate drought conditions. The binational commission of Maure-Mauri River basin developed a study to evaluate the water availability of the region, that was carried out using WEAP specifically to account for the representation and simulation of the basin.

The Binational Autonomous Authority of the TDPS Hydrological System (ALT), as the entity in charge of implementing the TDA and SAP, as well as conducting studies and projects related to the system. The team of coordinators and participants contracted by UNDP to develop the TDA, which includes experts from different academic and professional backgrounds, such as hydrology, ecology, sociology, economics.

2.2.4.2.6. Mahanadi River Basin (India)

At the state level, no government agency undertakes such works in the absence of the requisite expertize. However, at the central level the Central Water Commission, which has qualified professionals with proper training the relevant fields, undertakes such specialized modelling studies. It has recently embarked on modelling of all the major river basins of the country to reassess water resources in the wake of the changing hydrometeorological conditions using a water accounting tool.

2.2.4.2.7. Murray-Darling Basin (Australia)

This is largely accomplished by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Bureau of Meteorology (BoM) with additional modeling work conducted in Universities and state/federal government departments (e.g. South Australian Department for Environment and Water). All organizations' capacity would be deemed accomplished in these roles, although down-scaled models to assist localized adaptation remain a key research and information gap. A focus on socio-economic impacts remains a key concern for rural communities, farmers and politicians over environmental concerns and outcomes—leading to significant conflict around the SDL adjustment mechanisms going forward (see below).

2.2.4.2.8. Orontes River Basin (Lebanon)

The Ministry of Energy and Water, in the updated NWSS 2020 plan, the MoEW is responsible for developing a basin management plan that takes into consideration climate change to achieve climate-resilient water resource management using Water Evaluation and Planning System (WEAP) that adopts an integrated water resource management approach.

2.2.4.3. What stakeholders have expertise on business, environmental and socio-economic scenario development or similar skills (e.g. foresights and horizon scan, risk anticipatory skills):

Identify stakeholders with expertise on business, environmental and socio-economic scenario development or similar skills (e.g. foresights and horizon scan, risk anticipatory skills). These stakeholders are essential for understanding the potential impacts of water management decisions on the environment and society. They may include water users, as well as other organisation like research organizations and government agencies. Identify 1) key competences (including models), 2) participation in various water management processes, 3) grade their *qualitative and quantitative capacities (1- developing, 2- proficient, 3- accomplished), 4) identify existing modelling gaps (e.g., insufficient interaction with socioeconomic models) (build on your answer to Section 2.2.3).*

2.2.4.3.1. Júcar River Basin (Spain)

The **Confederación Hidrográfica del Júcar** (CHJ), which is the public entity that manages water resources at the river basin level, has key competences in water planning, allocation, monitoring and enforcement, as well as in river restoration and flood prevention. The CHJ uses various models and tools for water management, such as the AQUATOOL model for water allocation and drought management, the SAIH system for real-time hydrological information, and the SIMGES module for water quality. The CHJ participates in various water management processes, such as the elaboration and implementation of the River Basin Management Plan (RBMP) and the Drought Management Plan (DMP), as well as in the coordination and consultation with other administrations and stakeholders through the River Basin Committee (RBC) and the Learning and Action Alliance (LAA). The CHJ has a high qualitative and quantitative capacity (grade 3) for water management, but it faces some challenges such as the lack of coordination and cooperation with other regions and sectors, the existence of illegal or unregulated water abstractions, and the impact of climate change and droughts on water availability and quality. A potential modelling gap for the CHJ is the insufficient interaction with socio-economic models that could help to assess the impacts and trade-offs of different water management scenarios.

The **Asociación Valenciana de Agricultores (AVA-ASAJA)**, which is a farmers' association that represents and defends the interests of the agricultural sector in the Valencian Community. The AVA-ASAJA has key competences in promoting and supporting sustainable and profitable agriculture, as well as in providing technical and economic advice to its members. The AVA-ASAJA also participates in various water management processes, such as the **RBC**, where it represents the irrigation users. The AVA-ASAJA has a medium qualitative and quantitative capacity (**2**) for water resources management and scenario development.

The **Universitat Politècnica de València** (UPV), which is a public university that conducts research and education on various fields related to water resources management, such as hydrology, hydrogeology, water resource management, water quality, water economics, water governance, climate change, etc. The UPV has key competences in developing and applying models and tools for water resources management, such as the AQUATOOL decision support system (developed in-house), hydroeconomic models for water distribution and planning, the MODFLOW model for groundwater flow simulation, etc34. The UPV participates in various water management processes, such as the GoNEXUS project, which aims to develop a participatory approach for the integrated management of water, energy and food in the Jucar River Basin. The UPV also collaborates with other institutions and organizations, such as the CHJ, the MITECO, the EU, the Food and Agriculture Organization (FAO), etc. The UPV has a high qualitative and quantitative capacity (3) for water resources management and scenario development.

2.2.4.3.2. Nitra River Basin (Slovakia)

Ministry of the Environment and SAŽP have expertise in developing environmental and socio-economic scenarios (both scenario building and horizon scanning). SAŽP operates, at both, international and national level. SAŽP is a member of the foresight group within the European

Environment Agency´s Eionet network and have, for example, published on, scenarios for nature and biodiversity and on megatrends in Slovakia. Although SAŽP mostly focuses on qualitative assessment, it also has an experience in quantitative analysis.

2.2.4.3.3. Reno River Basin (Italy)

In Emilia-Romagna, there are nine **water boards** responsible for managing public reclamation and irrigation works, including canals and dewatering plants. These works are primarily intended for managing water drainage in low-lying areas without a natural outlet, as well as irrigation and water conservation. Land and property owners contribute to the boards' expenses. Maintenance activities, such as weeding and purging channels, ensure hydraulic efficiency. Maintenance of dewatering systems and mountain reclamation works ensures hydraulic safety. Through their infrastructure, the boards irrigate approximately 220,000 hectares of agricultural land using water from the river Po and its tributaries. The network of artificial channels in Emilia-Romagna covers approximately 19,800 km, comprising of 5,700 km of drainage channels, 11,000 km of mixed channels that serve both drainage and irrigation functions, and around 3,100 km of irrigation channels exclusively.

The **Renana water board** is a public entity that manages an area of approximately 342,500 hectares in the province of Bologna. With over 145,000 property owners as consortium members, the board supplies water for irrigation and production through a network of 1,615 km of canals, 51 hydraulic lifting systems, and 16 expansion tanks. Annually, they distribute 70 million cubic meters of water for production purposes and allow the outflow of over 400 million cubic meters of rainwater while safeguarding buildings and infrastructure.

Emilia-Romagna prioritizes the protection of biodiversity and sustainable management through its regional system of protected areas, Natura 2000 network, and ecological connection areas. These areas are managed by the Department for Protected Areas, Forests and Development of Mountain Area and form the regional ecological network, including parks, nature reserves, protected landscapes, and ecological rebalancing areas. Protected areas serve as natural buffer zones against floods and erosion and help maintain healthy ecosystems to support water availability and quality. The nature protection areas in the Reno basin play an essential role in water management by issuing permits and authorizations for activities that impact water resources and conducting monitoring activities to assess the quality and quantity of water resources. They also take measures to prevent and mitigate water pollution and other environmental threats.

ARTER is a consortium society of Emilia-Romagna which aims to enhance the sustainable development of the region through innovation research, attractivity and internationalization of the territory. ARTER has expertise on business, environmental and socio-economic scenario development.

ARPAE has expertise on environmental scenario development.

2.2.4.3.4. Tympaki River Basin (Greece)

The Region of Crete is responsible, among others, for the design and construction of infrastructure/ water works (dams, wells, water supply and distribution systems) it has a high influence on the overall water supply and allocation. It is also responsible for the design and implementation of measures. For these planning and management purposes they are often required to develop and examine different business, environmental and socio-economic scenarios (e.g. future projections on population, land use, business development, etc.), and they have expertise on this. Yet, it needs to be mentioned that they involve additional stakeholders and experts in this process. Capacity: 2- proficient.

2.2.4.3.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

There are two different actors, bilateral and national. In the case of bilateral entities, The Ministries of Foreign Affairs, Environment, and Water of Bolivia and Peru, as well as the implementing entities of the Integrated Water Resources Management (GIRH) as ANA Peru, MMAyA Bolivia, MINAM Peru are entities with capabilities to evaluate scenarios under the context of the system. They have a high priority in updating the Global Binational Master Plan and the Strategic Action Program (PAE) of the regional TDPS system which Caplina – Maure – Desaguadero is part of, for managing and coordinating the activities agreed between both countries.

In the case of National entities, ANA Peru has experience in conducting and evaluating environmental instruments, granting water use rights and authorizations, authorizing works in natural water sources, conducting studies, inventories, monitoring and risk management in glaciers, lakes and groundwater sources, and supporting participatory processes for dialogue and consensus building among water stakeholders. MMAyA Bolivia also provides environmental information (reports, statistics, indicators, maps) relevant to the Bolivian territory through its National Environmental Information System (SNIA), which facilitates access to data on environmental quality, climate change, biodiversity, water resources, soil degradation, solid waste management, among others. DGA Chile has experience in developing and applying water regulations, instruments, and standards, granting water use rights and authorizations, authorizing works in natural water sources, conducting studies, inventories, monitoring and risk management in water resources, and providing and disseminating the information generated by its hydrometric network and the Public Water Registry. They are entities which were contacted at the begging of the project and may play an important role in the activities of the living lab.

2.2.4.3.6. Mahanadi River Basin (India)

Generally such expertize are not available with any of the state or central agencies concerned with water resources in India. Such activities of scenario development that require multi-disciplinary skills are carried out through outsourcing to specialized consulting firms that engage experts from disciplines such as hydrology, hydrological modelling, climate modelling, water quality modelling, agricultural sciences, economics, etc.

2.2.4.3.7. Murray-Darling Basin (Australia)

As explained above, this remains an area of confusion, disagreement and poor outcomes with respect to effective data sourcing and analysis, agreed objectives and reasoning, and performance with respect to environmental gains over consumptive where clearly ecological requirements continue to play second-fiddle to economic concerns and goals. The MDBA has had responsibility for this for about a decade, and achieved little to no real progress making their capacity in this complex area at best developing.

2.2.4.3.8. Orontes River Basin (Lebanon)

The Ministry of Energy and Water (MoEW), the Ministry of Environment (MOE) and the American University of Beirut (AUB). MoEW and MOE are responsible for formulating policies, regulations, and strategies related to water management, with access to data, resources, and expertise necessary for scenario development and decision-making. And AUB plays a role in studying and analyzing the business, environmental, and socio-economic aspects of water management, with experience in conducting research, modeling scenarios, and assessing potential impacts.
For example, the Strategic Environmental and Social Assessment (SESA) of the updated NWSS-MoEW report asses the socio-economic (population growth, poverty, urbanization) baseline conditions to understand the state of the environment and specifically the current situation of the water sector in Lebanon.

2.2.4.4. What stakeholders have expertise on impact analysis, including economic, social, and environmental aspects?

Identify stakeholders with expertise in impact analysis. These stakeholders are necessary for understanding the potential economic, social, and environmental consequences of water management decisions. These stakeholders may include water users, government agencies, consulting firms, and academic institutions. Identify 1) key competences (including models), 2) participation in various water management processes, 3) grade their qualitative and quantitative capacities (1- developing, 2- proficient, 3- accomplished), 4) identify existing modelling gaps (e.g., insufficient interaction with socioeconomic models) (build on your answer to Section 2.2.3).

2.2.4.4.1. Júcar River Basin (Spain)

The CHJ has key competences in assessing and evaluating the economic, social and environmental impacts of water management decisions, such as water allocation, water pricing, water quality standards, drought management, etc.

2.2.4.4.2. Nitra River Basin (Slovakia)

The Ministry of Environment has the main competence in impact analysis, including economic, social, and environmental aspects. Other relevant actors include SAŽP, SHMÚ (Slovak Hydrometeorological Institute), SVP (Slovak Water Management Enterprise), and VÚVH (Water Research Institute). Other actors could include universities, for example Department of Hydrogeology, Faculty of Natural Sciences, Comenius University in Bratislava, Research Center Agrobiotech, Slovak University of Agriculture in Nitra, Department of Chemistry, Faculty of Biotechnology and Food Sciences, Slovak University of Agriculture in Nitra, and Department of Geotechnics, Faculty of Civil Engineering, Slovak University of Technology.

2.2.4.4.3. Reno River Basin (Italy)

Emilia-Romagna Region is the competent authority for impact analysis through an administrative tool called EIA (Environmental impact assessment). In the process of impact analysis, the Region is supported by Arpae, which provides preliminary investigations, AUSL (Local health unity Company) and the municipalities involved, which give their opinion on the matter. In some cases, the Region can promote public consultations and investigations, involving public administrations, institutions and parties involved. Another administrative tool operated by the Region is V.A.S. (Strategic environmental evaluations), it is similar to EIA but it concerns plans and programmes.

ARTER is the Agency of Emilia-Romagna Region which supports the Region in studies, innovation and knowledge. Usually for V.I.A., Emilia-Romagna Region asks for economic evaluations to ARTER.

2.2.4.4.4. Tympaki River Basin (Greece)

The following stakeholders have expertise in pressure and impact analysis: the Special Secretariat for Water of the Ministry of Environment & Energy, the Water Directorate of the Decentralized Administration (WDC), the Region of Crete. Capacity: 2- proficient.

2.2.4.4.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

MINAM Peru is the entity with capabilities to evaluate impact including, economic, social and environmental aspects. MMAyA Bolivia also provides environmental information (reports, statistics, indicators, maps) relevant to the Bolivian territory through its National Environmental Information System (SNIA).

2.2.4.4.6. Mahanadi River Basin (India)

The National Environmental Engineering Research Institute (NEERI), Nagpur has expertise in environmental impact assessment. For social and economic impact assessments, there are several research institutions affiliated to the Indian Council of Social Science Research. Every state has one socioeconomic research institute which is affiliated to ICSSR.

2.2.4.4.7. Murray-Darling Basin (Australia)

Apart from the MDBA, the main stakeholders involved in this space are the Universities where their research and analysis has focused on water trade, environmental governance and outcomes from watering, monitoring and assessments, policy analysis, farmer impacts and change, climate change impacts and adjustment needs, etc. In each case the Universities are proficient in this area with respect to analysis and provision of insights—with the caveat that governments don't always care for their advice or rely on it very much given the complex requirements around decision-making at their levels (see for example comments by Bishop and Boyle, 2019).

2.2.4.4.8. Orontes River Basin (Lebanon)

MoEW/ MOE/ CDR conduct environmental impact assessments. Water availability is assessed through a combination of field testing and modeling techniques, accounting for seasonal variability and projected changes in demand in the project area.

2.2.4.5. What stakeholders have expertise on risk assessment?

Identify stakeholders with expertise in risk assessment. These stakeholders are essential for identifying and managing potential risks associated with water management decisions. They may be similar to those above. (Early alert systems). Identify 1) key competences, 2) participation in various water management processes, and 3) grade their qualitative and quantitative capacities (1- developing, 2- proficient, 3- accomplished).

2.2.4.5.1. Júcar River Basin (Spain)

The Confederación Hidrográfica del Júcar (CHJ), which is the public entity that manages water resources at the river basin level. The CHJ has key competences in assessing and evaluating the economic, social and environmental impacts of water management decisions, such as water allocation, water pricing, water quality standards, drought management, etc.

2.2.4.5.2. Nitra River Basin (Slovakia)

Risk assessment in the river basins in relation to water abstraction for public consumption will be assessed for th first time until July 2027. The interval of such risk assessments will be carried out on a 6-yr basis taking into account requirements set in the Water Act 364/2004, § 4, 4b.

The Ministry of Environment is preparing an update of the National Adaptation Strategy which should be finalized in 2025. The new NAS will include climate risk assessment analysis, which is still missing in Slovakia to date. This risk assessment should include water sector as well. One of the objectives of the Water Policy 2030 is also to extend the monitoring network and develop early alert system for floods, which should be proposed by the Ministry by 2026.

Other relevant stakeholders in the risk assessment include: Ministry of Interior (mostly though in relation to floods management), SVP (e.g. a map server of the floods risk, early alert system at hydro plants, proposes when to announce 2 or 3 degree of flood risk), SHMÚ (meteorological and hydrological alerts, drought alerts and monitoring) and Public Health Authority (extreme heat warning, bathing water-quality monitoring). Each of the institutions play specific roles in the risk assessment in line with their competences.

2.2.4.5.3. Reno River Basin (Italy)

No detailed data for risk assessment associated with water management decisions is available. However, in Italy risk assessment in general is managed by insurance companies, which are all reunited under the National Association for Insurance Companies (ANIA).

2.2.4.5.4. Tympaki River Basin (Greece)

The Region of Crete has expertise in risk assessment. The different projects and water works' studies embed risk assessments. Capacity: 2- proficient.

2.2.4.5.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

The Binational Autonomous Authority of the TDPS Hydrological System (ALT), which oversees managing and coordinating the activities agreed between both countries, has jurisdiction to make actions to control international rivers in matters related to sedimentation and storm control, The operation of gates in the Desaguadero river at the exit of Lake Titicaca is in charge of ALT.

At national level in Peru, National Institute of Civil Defense (INDECI), which is responsible for coordinating disaster risk management at the national level. Other stakeholders include the private sector, civil society, academia, and international organizations such as the World Bank, the UNDP, and the GEF. Autoridad Nacional del Agua (ANA), the national water authority of Peru that is responsible also for water resources management and regulation and has declared states of emergency and created contingency funds for farmers affected by droughts in southern Peru, focused to improve or give them alternative water sources but not directly for the losses in agricultural production.

In Bolivia, the Viceministry of civil defense [VIDECI] is responsible for coordinating disaster risk management at the national level, there are some protocols to enable local committees. In the case of both countries forecast of climatic and hydrological risk is in charge of National Meteorological and Hydrological Service [SENAMHI].

2.2.4.5.6. Mahanadi River Basin (India)

The Central Water Commission has expertise in the assessment of risks associated with extreme rainfall events, i.e., floods. However the risk assessment involves assessment of the flood hazard in terms of the magnitude (of certain return period) and frequency of occurrence of floods (of certain magnitude) and not the exposure of the socioeconomic system to the flood hazards and the vulnerability of the communities to the disruptions in caused by the hazard which are essential for determining the degree of risk.

2.2.4.5.7. Murray-Darling Basin (Australia)

Universities and CSIRO / BoM in the main, where capacity is accomplished but little appreciated or necessarily understood politically/practically by users given complexity or risk (e.g., probability of allocation changes going forward) versus uncertainty (e.g., future water supply impacts of climate change across the MDB). Loch and Adamson (2023) discuss this most recently for the area.

2.2.4.5.8. Orontes River Basin (Lebanon)

The National Council for Scientific Research (CNRS) – Beirut developed a sustainable natural resources management platform and early warning system which includes flood hazard assessment and mapping.

2.2.4.6. What stakeholders have expertise on Policy analysis?

Identify Stakeholders with expertise in policy analysis. Identifying these stakeholders is necessary for evaluating the effectiveness of water management policies and proposing potential improvements. Identify 1) key competences, 2) participation in various water management processes, and 3) grade their qualitative and quantitative capacities (1- developing, 2- proficient, 3- accomplished).

2.2.4.6.1. Júcar River Basin (Spain)

The Confederación Hidrográfica del Júcar (CHJ), which is the public entity that manages water resources at the river basin level. The CHJ has key competences in assessing and evaluating the economic, social and environmental impacts of water management decisions, such as water allocation, water pricing, water quality standards, drought management, etc.

2.2.4.6.2. Nitra River Basin (Slovakia)

Ministry of the Environment of the Slovak Republic, SAŽP, SHMÚ (Slovak Hydrometeorological Institute), SVP (Slovak Water Management Enterprise), and VÚVH (Water Research Institute).

2.2.4.6.3. Reno River Basin (Italy)

Policy analysis is led by the Emilia-Romagna Region, in particular by the Department for soil protection, coast and land reclamation and the Department of Water Protection and Management, with the support of the State property area of Arpae and Civil Protection. The Region also involves river contracts in order to engage a high number of stakeholders.

2.2.4.6.4. Tympaki River Basin (Greece)

The following stakeholders have expertise in policy analysis (ex-ante and/or ex-post): the Special Secretariat for Water of the Ministry of Environment & Energy, the Water Directorate of the Decentralized Administration (WDC), the Region of Crete. Capacity: 3- accomplished.

2.2.4.6.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

From the surveys and interviews, there are specific institutions, entities, and sectors that are involved or have an interest in the policy analysis under binational agreements between Bolivia and Peru13, such as: i) political-institutional entities at the binational, national, and subnational levels, such as the ALT, the SUBCOMILAGO, and the ministries of foreign affairs, environment, water, and mining of both countries [Bolivia and Peru]; ii) civil society, such as local communities, indigenous peoples, farmers, fishermen, NGOs, and social movements has a very relevant political position considering that much of the governance mechanism rely on community associations [in pacific regional, there are water user committees, Maure – Mauri there are municipal committees and in Desaguadero at the downstream there are irrigation committees]; iii) scientific community, such as universities, research centers, experts, and consultants also have a very important role due to institutional memory about governance processes which governmental entities do not have due to staff rotation or change in the case of transboundary agreements; iv) private sector, such as mining companies, and service providers; v) international cooperation, such as UNDP, GEF, FAO, UNESCO, IUCN, WWF, and bilateral donors also play an important role due to impartial status and implementation of funds to coordinate both countries to move forward in transboundary water management14.

2.2.4.6.6. Mahanadi River Basin (India)

There are very few research institutions in India that have expertise in policy analysis. They are all in the non-governmental sector. The government agencies often engage them to understand the impacts of various policies introduced by them or to get ideas to frame new policies.

2.2.4.6.7. Murray-Darling Basin (Australia)

Again, this is mainly Universities with a interest and capacity in the area. As stated though, governments do not necessarily have to give any credence or attention ton these analyses and their insights, where politics plays a more dominant role. Capacity is arguably accomplished by the

Universities in the area—where additional funding and peer-review help to ensure credence of those providing policy lessons.

2.2.4.6.8. Orontes River Basin (Lebanon)

AUB-IFI (American University of Beirut - Issam Fares Institute) collected data on conflict risk factors, including socioeconomic indicators, water and environment indicators, and socio-political and water-related conflict indicators. Socio-economic variables such as poverty indices, population growth, livelihood diversity, and food security indices were considered. Water and environmental indicators included measures of water availability, quality, supply network coverage, and wastewater. Climate and natural disaster sub-indicators included temperature, precipitation, seasonality change, and history of natural disasters. Tension indicators were derived from social tensions perception surveys and water conflict events recorded in the ACLED database. These spatial indicators were used to calculate a composite water-related conflict risk score for each district. Baalbek and West Bekaa were identified as high-scoring hotspots. Root tensions and stakeholder interactions within these districts were analyzed. A survey was designed to explore the typology and drivers of water-related tensions, using social network analysis (SNA) to examine conflict resolution, knowledge exchange, water supply, quality, network maintenance, compliance, disaster risk reduction, water project funding, and key players in potential peacebuilding projects.

2.2.4.7. What stakeholders have expertise on participatory approaches to problem scoping and solution seeking?

These stakeholders may include community-based organizations, non-governmental organizations, and government agencies. Identify 1) key competences, 2) participation in various water management processes, and 3) grade their qualitative and quantitative capacities (1- developing, 2- proficient, 3- accomplished).

2.2.4.7.1. Júcar River Basin (Spain)

The Confederación Hidrográfica del Júcar (CHJ), which is the public entity that manages water resources at the river basin level. The CHJ has key competences in assessing and evaluating the economic, social and environmental impacts of water management decisions, such as water allocation, water pricing, water quality standards, drought management, etc.

2.2.4.7.2. Nitra River Basin (Slovakia)

To our knowledge, one of the stakeholders has built up expertise on participatory approaches to problem scoping and solution seeking. The competences of the organizations are sometimes not clearly and well communicated and participatory actions are missing not only at the regional but also national level.

2.2.4.7.3. Reno River Basin (Italy)

Stakeholders that have expertise on participatory approaches are the Emilia-Romagna Region, the local authorities and, mostly, river contracts.

River Contracts are stakeholders characterized by expertise on participatory approaches. They are voluntary participatory processes among entities that collaborate to enhance and valorize a land characterized by the presence of water (rivers, canals).

The Reno River and Bolognese canals contract is a collaborative and participatory tool aimed at scoping problems and seeking solutions concerning the river but not the entire basin, regarding environmental protection, fair management of water resources, valorization of river territories, safeguard against hydraulic risk and local development. At the moment, only the document of intentions has been signed but the contract itself will be signed in the future.

Another river contract concerning the Reno RB is the Santerno river contract; Santerno is a tributary of the Reno River.

2.2.4.7.4. Tympaki River Basin (Greece)

The following stakeholders have expertise in participatory approaches and in running public consultations (Capacity: 3- accomplished):

- The Special Secretariat for Water of the Ministry of Environment & Energy: heavily involved in the public consultation of the WFD RBMPs, and FRMPs
- The Water Directorate of the Decentralized Administration (WDC): heavily involved in the public consultation of the WFD RBMPs, and FRMPs
- The Region of Crete: heavily involved in the public consultation of the WFD RBMPs, and FRMPs, implementing participatory approaches in various water planning and management processes, consultations regarding planned water works, etc.
- The Local Land Reclamation Organization - TOEV of Zone A' of Messara: continuous interactions and consultations with the local farmers, participatory approaches for engaging the farmers in local irrigation management, water use monitoring, identification and reporting on water supply network problems, applying efficient practices and state-of-art technologies.
- The Municipality of Phaistos: continuous interactions and consultations with the local end-users on various issues
- The Municipal Water Supply and Sewerage Company of Faistos (DEYA Faistos): continuous interactions and consultations with the local end-users on various issues, sensibilisation and awareness raising on the consumers

2.2.4.7.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

In the case of diplomatic talks to participatory approaches to problem scoping and solution seeking for international water resources, ALT, and the ministries of foreign affairs, environment, water, and mining of both countries [Bolivia and Peru].

2.2.4.7.6. Mahanadi River Basin (India)

None of the government stakeholders, either at the state level or at the central level have expertise in employing participatory approaches to problem scoping and solution seeking. However, the local self-governing organizations in the rural areas (the Gram Panchayats) are mandated to engage with the village communities in micro planning of the developmental activities that they undertake. In the context of water, they include planning of watershed development interventions, water harvesting and artificial recharge of groundwater (under various schemes), and rural water supply.

2.2.4.7.7. Murray-Darling Basin (Australia)

Not applicable to any one specific group—all play some role here but resolution often remains a key problem. No-one can then said to be very capable in large-scale participatory solutions.

2.2.4.7.8. Orontes River Basin (Lebanon)

A Strategic Environmental Assessment (SEA) was developed by the NWSS and submitted to the MoEW with environmental recommendations. The BWE master plans provide recommendations for the CDR and MoEW.

2.2.5. What are the negotiation mechanisms in place, including for (transnational) conflict resolution, and the power relations?

Describe relevant conflicting interpretations of the law in the area, including transnational conflicts, and answer the following questions: is there is a Basin Council or a participatory instance/mechanism for conflict resolution? What mechanism is used to update the basin plan? How is the basin plan implemented and its enforcement supervised? What are the power relations in watershed management?

2.2.5.1. Júcar River Basin (Spain)

Some conflicts currently active in the Jucar River basin include:

- Conflicts between the Valencian Community and the Castilla la Mancha Community because of the Tajus-Segura water transfer. The Valencian Community supports the transfer as a solution to its water scarcity problem in the southern Alicante region, while the Castilla-La Mancha opposes it as a threat to its water resources and environment.
- Conflicts between Jucar and Vinalopo water users due to the Jucar-Vinalopo water transfer. The conflicts here include worries about the environmental damage to the Jucar system and the Albufera wetland, which could benefit from additional water inflows.
- The conflict between some environmental groups and some water users over the environmental flows for the Jucar River and its tributaries. The environmental groups advocate for higher environmental flows to protect and restore the ecological status of the river and its associated habitats, such as wetlands and lagoons. The water users, especially irrigation users, oppose higher environmental flows as a limitation to their water availability and use.

The mechanism used to update the basin plan is the River Basin Management Plan (RBMP) for the Jucar River Basin, which is a strategic document that defines the objectives and measures for water planning and management in the river basin. The RBMP is developed and implemented by the Confederación Hidrográfica del Júcar (CHJ), in coordination and consultation with other institutions and organizations, such as the regional authorities, the municipalities, the water users, the environmental groups, etc. The RBMP is updated every six years, following the cycle established by the Water

Framework Directive (WFD). The current RBMP covers the period 2022-2027 period and it was approved early 2023.

The basin plan is implemented and its enforcement supervised by the Confederación Hidrográfica del Júcar (CHJ), which is the public entity that manages water resources at the river basin level. The CHJ is responsible for granting concessions and authorizations for water use, setting and collecting water tariffs, monitoring and controlling water quality and quantity, enforcing water rights and sanctions for non-compliance, implementing measures and actions for water conservation and protection, etc. The CHJ reports to the Ministry for Ecological Transition and Demographic Challenge (MITECO), which is the central government department in charge of water policy and legislation. The CHJ also collaborates with other institutions and organizations, such as the autonomous communities, the municipalities, the water users, the environmental groups, etc

The power relations in watershed management are influenced by various factors, such as the political, economic and social weight of the different water users and stakeholders, the legal and institutional framework for water governance, the availability and distribution of water resources, the degree of participation and involvement of the public, etc. In general, it can be said that the power relations in watershed management are dominated by the Confederación Hidrográfica del Júcar (CHJ), which is the main authority for water planning and management in the river basin, and by the irrigation communities, which are the largest and most organized water users in the river basin

2.2.5.2. Nitra River Basin (Slovakia)

To our knowledge, no other mechanisms are in place beside the RBMP for the Váh RB that Nitra RB is located within. RBMP is developed in participatory way with the relevant stakeholders and public and updated every six years in line with the WFD. RBMP is enforced by all the state water authorities including water manager (SVP), district and regional authorities, as well as by the Ministry of Environment.

As for the transnational level, Slovakia is, for instance, a member of the Danube River Protection Convention (ICPDR), which forms an overall legal instrument for co-operation and transboundary water management in the Danube RB. The main objective of the ICPDR is to ensure that surface waters and groundwater within the Danube RB are managed and used sustainably and equitably. There are also commissions for the transnational rivers for each of the neighbouring countries (HU, UA, POL, CZ). Within each commission, there are topical sub-groups working on WFD implementation and other issues.

The competent authority for the updating the basin plan – Ministry of Environment (MoE) is responsible for compilation, update and coordination of the basin plan approval by government of SR. MoE is also responsible for communication with other relevant sectors/ministries. The sub-ordinate organizations (SVP, SHMÚ, VÚVH, SAŽP, ŠGÚDŠ) within the network of MoE are organized in different working groups and have different roles and responsibilities. Each year, specific tasks are defined by MoE that should be solved – this is very dependent on finances available/allocated by government for a particular year. Financing is too much dependent on actual political situation.
Concerning the implementation and enforcement of the basin plans, there is a controlling mechanism at the MoE and the competencies and duties are well defined. In general, there is a lack of finances, capacities and employes are often overloaded.

MoE has the main power and should communicate its priorities with other relevant sectors, municipalities and self-governing regions. It´s often difficult to find compromise via discussions and engagement is very rare. Participatory principle is still rarely implemented in practice in Slovak conditions.

2.2.5.3. Reno River Basin (Italy)

There are several memoranda of understanding (MoU) by which it is decided how to manage conflicts among regions. All the basin authorities are involved in the procedures of authorization and planning, based upon the concept of taking into account interregional issues and the districts as planned by national legislations.

In general, Tuscany, which owns a small part of the Reno River, entrusts the Emilia-Romagna region to run the territory and water services. For the Santerno area and its tributaries towards Romagna, there are similar agreements, in fact, both the Emilia-Romagna and the Tuscan parts of the river are managed by West Romagna LRB (Consorzio di bonifica della Romagna Occidentale).

2.2.5.4. Tympaki River Basin (Greece)

Water allocation rights are well defined, though water use licenses and specific arrangement so no major conflicts arise. The roles and responsibilities of the competent authorities are also very well defined through the existing legislation (specific Law, clarifying application/interpretation text of the Law, Joint Ministerial Decisions, etc.) leaving no room for miss-interpretation or conflict. In the case of new water works being implemented, these need to have acquired all necessary licenses from all relevant bodies (e.g. environmental permits, permits from antiquities authority, etc.) before they can commence. A relevant Committee for the Supervision and Acceptance of a water work is also always formed by the funding authority of the work, usually the Region of Crete. In the case any conflict arise between neighboring Local Land Reclamation Organisations (TOEVs) which might share irrigation water from common sources, the Region of Crete has a dedicated Supervisory Committee for the TOEVs which support conflict resolution and monitors the smooth operation of the TOEVs. In the case of appeals against higher-level Decision issues are taken to the Council of State or Court.

The River Basin Management Plans are updated according to the WFD implementation cycles. The competent authorities responsible for the implementation and enforcement of the different measures of the RBMP are specified within the plan.

2.2.5.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

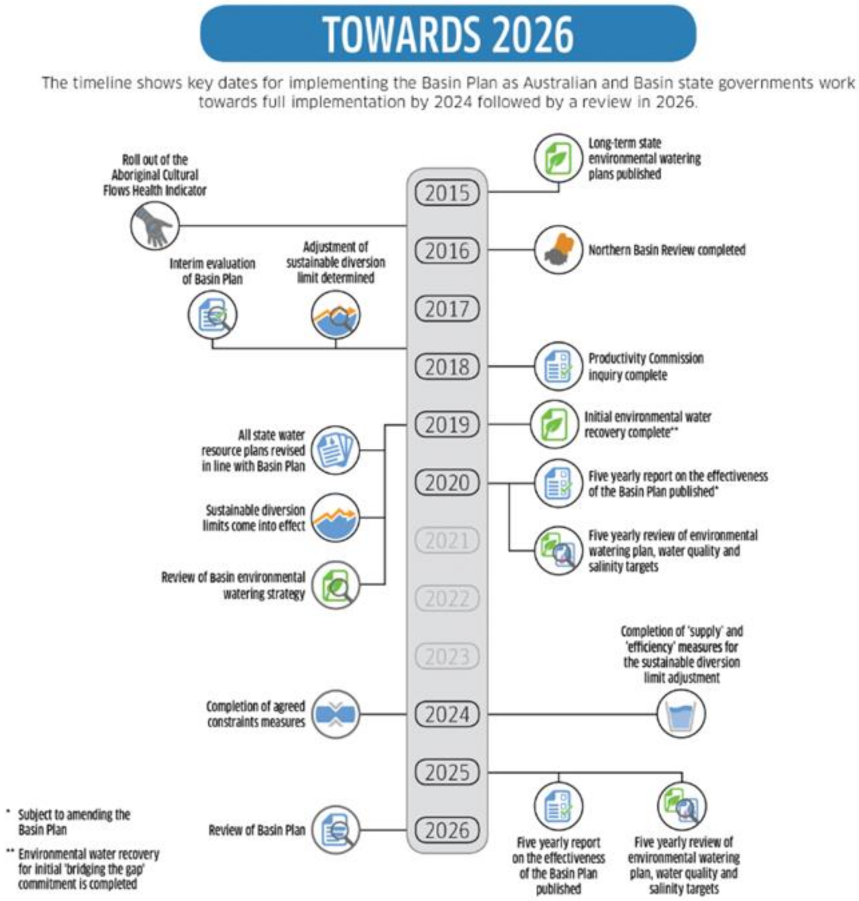
In the case of diplomatic talks to manage negotiation for international water resources, ALT, and the ministries of foreign affairs, environment, water, and mining of both countries [Bolivia and Peru] are the main decision makers, these entities created a specific technical committee for Maure – Mauri [CTB]. These activities do not have official or binding agreements or protocols and rely on the good conversations of both governments to move forward; therefore, the conflict resolution depends on these structures in the case of all system for the project.

2.2.5.6. Mahanadi River Basin (India)

The only negotiation mechanims available in the case of disputes (between states) is the Mahanadi Water Disputes Tribunal, constituted by the Ministry of Jal Shakti. The state govenrments can present their case to the Tribunal

2.2.5.7. Murray-Darling Basin (Australia)

Rarely an issue in Australia, but if warranted the process usually involves the Courts in the relevant state jurisdiction. As rights always vest with the states, and are legally only 'rented' to water users over time, hence the power to resolve conflicts is quite strongly geared to governments. First in time or first in right arrangements were not adopted in Australia (thankfully), meaning that if necessary all rights could be cancelled and reallocated by the state (arguably) without compensation (for an example see Queensland Parliament, 2000); providing a powerful motive for users to get along. The MDB Basin Plan is updated around every 5-years (next review for MDB due 2025 and to be implemented in 2026), where a framework for this process is as shown below:



The timeline shows key dates for implementing the Basin Plan as Australian and Basin state governments work towards full implementation by 2024 followed by a review in 2026.

Source: https://www.mdba.gov.au/report/basin-plan-annual-report-2015-16/looking-ahead/towards-2026

However, despite strong governmental power relations, MDB irrigators continue to hold a strong yet slowly diminishing political and economic power advantage at present despite billions invested in the national good for environmental rights and access to water since 2005.

2.2.5.8. Orontes River Basin (Lebanon)

The Syrian Lebanese Joint Committee for Shared Water coordinates cooperation between Lebanon and Syria for managing shared water resources. They signed agreements in 1972 and 1994 that regulate water use in the Orontes River basin, considering it as shared water and allocating specific shares to each country. The Orontes River Joint Committee manages water resources and is funded by Syria. It handles technical aspects and promotes communication. A joint arbitrary committee evaluates commitment to the agreements and resolves conflicts. The negotiation mechanisms between the two countries are influenced by history, politics, and recognition of the Orontes River as international. The aim is to ensure fair water distribution and maintain balance.

2.3. Economic policies and instruments

2.3.1. How does the tariff system work in the area?

Describe the tariff system, including type of tariffs (surface and groundwater), whether tariffs are earmarked, whether tariffs are volumetric, what institution raises the tariff, degree of cost recovery (distinguishing between financial, environmental and resource costs recovery). Identify key barriers and challenges hampering performance of the tariff system.

2.3.1.1. Júcar River Basin (Spain)

In Spain, water charges are raised in the form of a water use tariff and a regulation fee. These charges are earmarked towards water management expenditures and are raised by the River Basin Authority. Tariffs should recover according to the EU WFD resource, environmental and financial costs—although only the latter are (partially) recovered.

The payment systems vary depending on the water source and the irrigation system used. In traditional irrigator communities that use surface water, users make an annual payment according to the surface under irrigation. In more water stressed communities, a dual payment system applies that includes a payment for the surface under irrigation and a payment for the time during which the land is being irrigated. Where more efficient irrigation systems are in place (drip irrigation), a volumetric system is applied (amount of water consumed). In the case of surface water, the cost recovery ranges from 54 to 98%. In the case of communities supplied with groundwater, the cost of the infrastructures is paid by the users through the quotes paid, so the cost recovery is 100% (this figure only refers to financial cost recovery—no environmental or resource costs are recovered).

2.3.1.2. Nitra River Basin (Slovakia)

The water management system works on the principle that the users and the polluters pay for the water management services. Polluters or discharge of polluted water tariff system for the services of the water management defines the collection of laws no. 755/2004 Z. z. and the polluters pay only if they exceed the limits for the volume of the discharged polluted water and concentration and variation of the specific pollutants. While the pollution from the agriculture sector is ton considered and no payments are defined. There are only payments for polluting waters through environmental tax and is considered to be among the lowest in the EU. This is applicable also for discharging agriculturally polluted water to surface waters and groundwater.

The fees (based on collection of laws no. 755/2004 Z. z.) for using the groundwater are set to reach its minimum in 2025 and should achieve the fees set for the use of the surface waters.

Water management services including water supply through the public piping system and for the cleaning of the discharge water is covered up by the water management companies (655 of them were registered until 2018) and municipalities (41). Charges for the surface water is equal for the household use and the industry. Price of the surface water established in 2018 and applicable for one cubic meter of water was 2.0521 euro (this price is set from two parts, first 1.0518 for the drinking water, and second 1.0003 for the discharge). Surface water-withdrawal payments cover the costs of the water management services provided by the water manager and the withdrawals are charged if the abstraction exceeds 1250 m^3/month or 15 000 m^3/year. In case of abstraction for irrigation, water users are charged if the volume exceeds 50 000 m^3/year. Water use for hydroenergy is charged based on whether the hydroenergetic potential of the water course is used in a dam managed by the water manager (SVP, power generation above 100kW) or whether the water is abstracted from the water dams owned by the user and the installed power generation exceeds 10MW. Water withdrawals as mentioned above, but except for irrigation, are charged based on the decision of the Office for Regulation of Network Industries (ÚRSO). Water withdrawals from the surface waters for irrigation exceeding 50 000 m^3/year are charged the same as withdrawls of groundwater for irrigation (0,001 eura/m^3). Irrigation of organic farming is freed from water charges. Water withdrawals for irrigation are paid to the respective water manager.

Groundwater abstraction (except abstraction for irrigation) is charged if the abstraction volume exceeds 1250 m^3/month or 15 000 m^3/year. Even if the abstraction exceeds 1250 m^3/month only in one calendar month, the water user is charged for the whole calendar year).

Surface and groundwater abstraction for irrigation is charged if the water withdrawal amount exceeds 50 000 m^3/year. Government regulation No. 755/2004 Coll. based on the Water Act No. 364/2004 Coll. sets the tariffs for the public water supply to be 0,0332 eura/m3. Withdrawals for livestock production (drinking and sanitary water) are set at 0,0232 euro/m3. Withdrawals for irrigation are charged 0,001 eura/m^3 (including withdrawals from surface water). Abstraction of geothermal and other groundwater for energy use is charged 0,0266 euro/m^3, and groundwater withdrawals for other uses are charged 0.0996 euro/m^3.

The price for the water production, distribution, and delivery by the public water supply network is determined by the Water Operating Company in accordance with the regulation set by ÚRSO and the Act 323/2022 Coll. The study area falls under the Central-Slovakia Water company who determined the tariffs to be currently 1.871 euro/m^3 for production and delivery, and 1.03 euro/m^3 for the distribution of the drinking water.

According to the objectives of the new Water Policy Concept 2030, the Ministry of Environment is responsible to develop until 2030 a complex reform of tariff system for water use including water management services, use of water works, and water as a commodity. The tariff system should be based on the principle "the user and the polluter pays". This will also include implementing a two-part (fixed and variable part) tariff system (which was introduced for a short period of time in 2017), reassessing tariffs for releasing contaminants, reassessing limits for surface and groundwater abstractions. The Ministry, in coordination with SVP, SHMÚ, and WRI, is supposed to propose legislation until 2024 for implementing a mechanism for prioritizing the water users in case of water scarcity or drought. This would serve as some kind of traffic lights specifying who has a priority for water abstraction in case of scarcity.

2.3.1.3. Tympaki River Basin (Greece)

Irrigation water tariffs: Every year at the annual general assembly, the elected members of the Local Land Reclamation Organisation (TOEV of Zone A' of Messara), which is responsible for irrigation water supply, decide the annual tariff for each cubic meter of water. The billing price is adjusted according to the energy, operational and development costs of the organization. Every six months invoicing and bills are issued, based on the metered volumetric consumption of each member/user. In the event of non-payment of the bill, the member/user is automatically informed and if there is no response within a designated time period, the member's access to the water supply, is interrupted. The current water tariff is 0.19 euros/m3 of water.

Dirking water tariffs: The price of the potable water depends on the type of end user (domestic use, commercial, oil olive mills, construction site), the water source (springs vs. wells) and the consumption volume. Metering and invoicing is monthly, but the water bills are issued semi-annually. The tariff system of DEYA Faistos includes (https://www.deya-festos.gr/#DEYAF-WaterPrice):

- the value of the consumed water, based on the volume registered in the meter and a block tariff system according to the user type (see Table below)
- fees (fixed fee based on the consumed volume, maintenance fee 0.6 €/month)
- a special fee (80% of the value of consumed water according to Law 1069/80 to be used for study, construction, reconstruction or extension of water and sewage works)
- a sewer usage fee (70% of the value of the consumed water, applied to the consumers where there is a sewer network of independent sewers and only for the areas where the DEYA Phaistos has a recipient of wastewater collection)
- a fee for the use of stormwater collection networks (30% of the value of consumed water, applied to consumers who are not subject to the sewer usage fee)
- an environmental cost fee (0.012% of the value of the consumed water, according to the Decision of the National Water Commission 135275/2017 containing the general rules for costing and pricing of Water Services, as well as the method and procedures for cost recovery of water services in its various uses)
- a 13% VAT (on the value of the consumed water) or 24% VAT (on the fees)

Table: Domestic water prices of DEYA Faistos per m3 per type of user for the Tympaki areas

Type of User	**Volume consumed/m from - up to**	
Residential *discounted rates apply for households with 3 children (30% discount), 4 children and above, and handicap people (40% discount)*	0 – 17.50 m3	
	17,51 – 27.50 m3	0.35 €
	27,51 – unlimited	0.95 €

Commercial (offices, shops, etc.), Farmhouses, Livestock houses	0 – unlimited	0.50 €
Governmental and public, public institutions, schools, public benefit organisations	0 – unlimited	0.26 €
Fish farms, oil mills	Flat rate of 83.33 € per month	
Construction sites (during works)	0 – unlimited	0.80 €
Hotel businesses	0 – unlimited	0.50 €
Oil mills, concrete production companies	0 – unlimited	0.26 €

2.3.1.4. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

In the pacific region [Caplina, Locumba and Sama basins], there are systems of tariffs for each water user according to a yearly planning system which is coordinated through Local Water Administrator [ALA]. ALA defines an annual budget that is calculated considering operating costs of maintenance of the water intake and distribution systems, necessary technical personnel, and administrative costs for the National Water Authority [ANA] that are allocated to hydrological studies and specialized personnel in the national offices and regional. These costs are distributed to all users that are part of ALA and would be the unit tariff managed to water use.

In the case of the Maure - Mauri and Desaguadero region, the management method is similar for drinking water consumption through municipal cooperatives, the tariff system is defined and reported to AAPS, which is the national water authority in the case of Bolivia for drinking water services specifically, the schemes that are handled are usually by blocks and levels of volume consumed. In the case of the irrigation system, there is no regulatory authority such as ANA in Peru. The irrigation committees are autonomous and have contribution schemes [Tariffs] that exclusively cover operational aspects of maintenance.

2.3.1.5. Mahanadi River Basin (India)

In the Indian states of Chhattisgarh and Odisha, there are no water resource fee or tax levied by the agencies that supply water, either for irrigation or for drinking water supply or for manufacturing. The water charges that the agencies (such as the water resources department) recover from the users are meant to cover a small portion of the operation and maintenance cost of the scheme. In the irrigation sector, pricing of water is not done volumetrically and charging for water is based on crop type and the area irrigated. In the case of urban water supply, only a small fraction of the water connections are metered. Only the bulk water users are metered and charged on pro rata basis. In the rural water supply sector, there is no metering of the household water connections.

2.3.1.6. Murray-Darling Basin (Australia)

Most tariffs involve two-parts: a volumetric charge based on extraction/consumption by the users, and fixed annual charges regardless of use to cover annual expenses. Other tariffs apply to water trade activity, drainage costs in managed supply systems, meter charges for shared IIO costs (e.g. channel cleaning), termination fees if selling rights, etc. Examples for GMW are provided below:

Charge category:	Value	Unit
Annual service fee	110.00	$
Annual infrastructure access fee	2870.00	$
Termination fees	28700.00	$
Annual drainage service fee	110.00	$
Bulk water charges (high reliability entitlement)	7.20	$/ML
High reliability entitlement storage fees	10.70	$/ML
Change of ownership fee	80.00	$
Copy of title record	25.00	$
Issue/cancelation of water share	193.00	$
Application to trade water allocation using GMW pool desk (buy or sell)	85.90	$
Drainage diversion agreement fee	2.15	$/ML
Buyer brokerage fee	1.50	% of total
Seller brokerage fee	3.00	% of total

For a comprehensive example of fees and tariffs see the GMW site. These tariffs will vary for other IIOs and state/federal agencies.

2.3.1.7. Orontes River Basin (Lebanon)

There are no specific water tariff regulations in the Lebanese text laws. According to the text law 221/2002 “water establishments will be in charge each within its region and competence of putting tariffs for potable, irrigation and wastewater taking into consideration social, and general economic constraints”.

Tariffs fixed by LRA and water establishments: A flat rate tariff, where subscribers pay a flat annual rate based on a consumption of one cubic meter per day. However, tariffs are disconnected from the real consumption of water, unrelated to the quantity of water distributed, and uncorrelated with the effective cost of water production and distribution. In 2022, the government approved a new Water Establishments’ tariff for the annual water bill of between LBP800,000 and LBP1 million ($32-$46) per household per year for a maximum of 1 cubic meter a day (3 per cent of the minimum wage and allowances).

2.3.2. How are water trading arrangements regulated and working?

Is water tradable? Is there a use it or leave it clause that affects trading? What type of markets exist, spot market (bilateral trading, not centralized market), exchange centre (clearinghouse), other? Who participates in the trading? (Public, private) Are there option contracts or futures? Are trading reallocations temporary or permanent? Are there reported cases of illegal water markets? Identify key barriers and challenges hampering water trading implementation.

2.3.2.1. Júcar River Basin (Spain)

The water rights in Spain are tradable, but with some restrictions. They are mainly for use purposes, and there is a public register or census to keep track of them. There is a use it or leave it clause in place, which may lead to revocation of the license for non-effective use, although this is rarely enforced.

Furthermore, there have been ongoing reforms to the Spanish Water Law. In 1999, the law was amended to allow water use right holders to exchange their water concessions for temporary or long-term contracts, enabling water trading. In 2003, the law was further adapted to incorporate the Water Framework Directive (WFD), which required river basin management plans to be adapted to the WFD's objectives. The establishment of eflows allows to modify preexisting water rights without compensation, in line with the Water Act which allows to revoke or modify existing rights without compensation where these affect third parties including the environment.

Enforcement of regulations in the water market is not consistent, with some black water markets existing alongside legal ones (Hernández-Mora and De Stefano, 2013). Spot markets are commonly adopted. Both public and private participants are involved in the market, and there are currently no option contracts or futures trading available. The market operates under a temporary legal decree (no permanent water markets exist).

2.3.2.2. Nitra River Basin (Slovakia)

The water is non-tradable resource in Slovakia as it belongs to the state according to the Constitution. All of the above-mentioned water management services are paid services, which are subject to regulation through the Regulatory Office for Network Industries, except for the water service "abstraction of surface water for irrigation for farmers", for which the fee is set by the Slovak Republic Regulation No. 394/2016 Coll., which amends Slovak Republic Regulation No. 755/2004 Coll., and the provider of the service is SVP. Water abstracted from the surface or groundwaters cannot be exported outside the Slovakia (except some small amounts for personal use) except for humanitarian purposes under some restrictions.

2.3.2.3. Reno River Basin (Italy)

Water trading in Italy is illegal. A 2011 referendum negated the possibility to exact profit from water provisioning services (GU, 2011). A major risk of trading in the Reno is the number of sleeping licenses which could be activated with trading, due to the market value of water and its tradability.

2.3.2.4. Tympaki River Basin (Greece)

The water rights are not tradable. No water markets exist. In the case that a group of farmers has a water use license (from utilizing a private well) and one of them wants to step out of the group, he/she has the option to transfer his/her original right (for this particular well) to another farmer (subject of course to the common acceptance of the remaining farmers in the group), yet a new license which includes the new names will need to be issued.

2.3.2.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

In the system is a transboundary basin shared by Bolivia, Peru and Chile, water trading arrangements are not well developed or documented. However, there are some examples of informal and bilateral agreements between neighboring users or countries to share water resources for different purposes, such as irrigation, hydropower, domestic use, and environmental protection for Peru and Bolivia specifically. Some of these agreements are based on historical rights, customary practices, or mutual benefits, while others are influenced by political and diplomatic factors. The main challenges for water trading in this basin are the scarcity and variability of water availability, the lack of reliable and updated information on water supply and demand, the potential conflicts over water rights and interests, and the need for coordination and cooperation among different stakeholders and institutions at local, national, and regional levels.

In the case of diplomatic talks, ALT, and the ministries of foreign affairs, environment, water, and mining of both countries [Bolivia and Peru] are the main decision makers, these entities created a specific technical committee for Maure – Mauri [CTB]. CTB is working to produce management models to quantify the water potential of the basin in natural conditions, using the soil moisture balance method, calibrated, and validated with hydrometric information available in the stations installed by both governments in the basin, an initial model available on WEAP platform. CTB expects to use these models to be the technical basis for defining water availability and shared water use scenarios for the implementation of projects and implement water trading between users. These activities do not have protocols and rely on the good conversations of both governments to move forward. This procedure is key because the Pacific region, Maure – Mauri and Desaguadero depend on water allocation from Maure-Mauri River basin.

2.3.2.6. Mahanadi River Basin (India)

There is no formal or informal water trading is reported to be happening in the basin between sectors and within sectors. However, informal trading of groundwater in the irrigation sector is a phenomenon in many water-scarce regions of India. Also, there is informal trading of water between agriculture and urban domestic sector (between farmers and Municipalities) in certain pockets.

2.3.2.7. Murray-Darling Basin (Australia)

Water trade arrangements came into place on July 1 2014, and are regulated under Schedule 3 of the Water Act (2007), which sets the rules and objectives for all Basin partner states—although they also have their own water trade rules and regulations (e.g., NSW Parliament, 2000). Each state is also represented by a water trade manager within the MDBA. Water trade is working well across the Basin to reallocate water as needed during periods of low supply (Wittwer and Griffith, 2011); although some issues do crop up to challenge and question water trade gains, rules and benefits such as recent concerns around speculation and hoarding of water to the detriment of agricultural users—found to be of little merit or cause for actual concern (Loch et al., 2021).

2.3.2.8. Orontes River Basin (Lebanon)

According to the Water Law, water is a national resource the quality of which must be preserved, as must the Lebanese State's rights to internal, regional, and international water sources. MoEW has the power to manage publicly owned water properties. Water is publicly owned and may not be possessed, owned, or acted upon in any way.

2.4. Insurance policy in case of droughts or water scarcity

2.4.1. What insurance types are in place and how are they financed (focus on agriculture)?

Describe the insurer (commercial/mutual funds, public/private), loss assessment mechanism, type of damage insured (yield, revenue, income), rainfed/irrigated, permanent/ligneous/annual crops, subsidies and state aid (including access to EU Solidarity Funds), reinsurance (public, private, mechanisms), and the conditions (drought, lack of water, water availability lower than water rights...) under which they apply. Identify key barriers and challenges preventing higher insurance penetration rates.

2.4.1.1. Júcar River Basin (Spain)

Drought insurance only applies to rainfed agriculture. The institutional risk of water resources management, coupled with significantly higher profits in irrigated agriculture, is too high to be assumed by the insurer.

The insurer is a commercial entity, which covers the risk for the yield. The loss assessment mechanism used by the insurer is on-site, which involves evaluating losses directly in the affected areas rather than relying on an index-based system.

The insurer type for the rainfed-farming crop insurance scheme is a combination of both public and commercial insurance providers. The Public Insurance Compensation Consortium operates as a reinsurer participating in the coinsurance pool, with a 10% share of the risk, and offers non-proportional reinsurance through a stop-loss treaty, in collaboration with commercial insurance companies. Additionally, the crop insurance scheme benefits from subsidies provided by ENESA, the National Agricultural Insurance Entity. Potentially, there is also the possibility to gain access to the EU Solidarity Fund (The European Union Solidarity Fund (EUSF) was set up to respond to major natural disasters and express European solidarity to disaster-stricken regions within Europe, in those events where losses exceed some predefined thresholds). Commercial insurance, particularly in irrigated agriculture, could take on the role of water (particularly GW) as insurance capital, which leads to overexploitation during droughts (Gómez and Pérez-Blanco, 2012).

2.4.1.2. Nitra River Basin (Slovakia)

The Ministry of Agriculture and Rural Development (MPRV SR) recently (April 2023) proposed a strategic document for establishing a "Risk fund" for farmers that would be a more systemic solution to cover larger-scale losses in case of extreme weather events, climate change, pests, etc. The document was reviewed by other ministries and stakeholders and is not legally bound yet. It will be funded by, both, the MPRV SR and the member farmers. The farmers will pay a fixed and a flexible part of a membership.

Beside this fund, there are private Insurance companies, the biggest one specialized in insuring agriculture being Agra poisťovňa, who is also a member of AIAG (Association Internationale des Assureurs de la Production Agricole). This company uses INCA-ZAMG model (Vienna) for the precipitation deficit, hence, the drought is not measured in the field, but assessed against a reference value modeled using the INCA-ZAMG model and fed by meteorological data.

2.4.1.3. Reno River Basin (Italy)

There is commercial insurance, as well as mutual funds, which offer yield insurance for agriculture against droughts, only for rainfed agriculture. Loss-assessment is on-site. Liability is shared between private insurers and the public. Reinsurance is private & public:

- Non proportional reinsurance through a stop-loss treaty that protects the company budget when the indemnity to premium ratio of the insurance policy is between 90% and a maximum of 160%. The reinsurance fund is funded through a levy over the premium paid by insured agents that ranges between 8% and 14%. The fund may cover a maximum of 70% of the insured value. This system is applied for the pluririschio insurance, a type of combined insurance in Italy.

- Proportional reinsurance for other insurance systems through the quota share system, where insurer and re-insurer share premiums and risk. The insurance companies have to pay the reinsurance fund at least 80% of the premiums that fall under the fund's share. The fund may cover a maximum of 50% of the insured value. This system is applied for the multirischio insurance, another type of combined insurance in Italy.

There is state aid through ex-ante subsidization and ex-post public re-insurance (stop loss treaty), and the possibility to access EU funding through the Solidarity Fund. Premium subsidization in Italy has "a maximum threshold of 80% of the premium cost for insurance contracts against catastrophic natural disasters, in case the deductible amounts to at least 30% of the insured production (20% in the so-called disadvantaged areas –comprising mountain and hill farming and other less favoured areas). The maximum threshold for premium subsidization falls to 50% in case the insurance contract also covers other damages outside the range of catastrophic natural disasters" (Pérez-Blanco et al., 2014). Commercial insurance, particularly in irrigated agriculture, could take on the role of water (particularly GW) as insurance capital, which leads to overexploitation during droughts-this creates relevant synergies between insurance companies and the supply of ecosystem services e.g. through NbS.

2.4.1.4. Tympaki River Basin (Greece)

In case or natural disasters the Ministry of Economics is responsible for insurance and compensation. The Ministry of Rural Development and Food is also responsible for farmers, for compensation through the Hellenic Organization of Agricultural Insurances.

In case of drought or water scarcity there is no insurance, neither compensation yet.

2.4.1.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

Under the water management plans at national or local levels there is no articulated insurance for specific events such as drought or water scarcity. At national level in Bolivia the regional and national governments are responsible to declare emergency which enable specific economic resources to implement mitigation measures in terms of infrastructure, one example was the drought in the season 2016/17 in the Andean region which impacted La Paz city the capital of the country for which investment to improve and create new intakes for the supply system of the city were deploy with a simply protocol of approval, however there is no specific schemes of insurances in the Bolivian financing system. There is pilot program funded by Bill and Melinda Gates foundation called International Labour Organization [ILO] one the first in Latin America which gives triple protection to small farmers against loss of crops due to drought, frost, hail or floods and other climate adversities15, but the main area with experience remains at the south of the country not in the system for the project.

In Peru the situation is kind of similar than in Bolivia, but there are pilots to support the transition to apply this financing schemes. Funded by the World Bank, the project "Advancing policy reforms in Peru to reduce risk from natural hazards" introduce policy reforms under the consideration of the government to strength the financial protection, public investment, and critical infrastructure for disaster risk management, including droughts. ILO is also operative in Peru, but works: 1) providing technical assistance and policy advice to the government on labour law reform, social protection extension, employment promotion, gender equality, indigenous rights, and green jobs; 2) supporting the development and implementation of a national strategy to prevent and eradicate forced labour; 3) strengthening the capacities of workers' and employers' organizations to participate in social dialogue and collective bargaining; 4) promoting the formalization of informal workers and enterprises, especially in rural areas; 5) enhancing the prevention and elimination of child labour, especially in hazardous sectors such as mining, agriculture, and domestic work; 6) facilitating the access to decent work opportunities for Venezuelan migrants and refugees and their host communities; and 7) providing guidance and tools to mitigate the impact of COVID-19 on workers' health, income, rights, and employment, there is no information about pilots from ILO about insurance to small farmer as we described in the case of Bolivia.

In both cases the mechanism depends on the existence of a national monitoring systems which may be utilized to stablish when the insurance can be implemented however, this kind of systems are in development and after some interviews to local stakeholders we can assume the project could help to show the effectiveness of such mechanisms.

2.4.1.6. Mahanadi River Basin (India)

There are no general insurance policies in place to cover the damages due to droughts and floods in the sense that there are no policies which can benefit all water users, including bulk water users like municipalities and industries during such natural hazards for the losses that they have to bear as a result of disrupted water supplies or damage to water supply and other infrastructure. However, there is crop insurance available for farmers, for which they have to pay a small premium, which covers not only droughts and floods but also damages due to diseases.

2.4.1.7. Murray-Darling Basin (Australia)

There is little insurance protection for agriculture in general in Australia. Some very high-value crops (e.g. cotton) can access hail damage insurance cover for the early part of a season, protecting form catastrophic loose early in a season. But other protections are not offered or available in the ag industry. Typical flood protection may be on offer for infrastructure losses, but this is considered by many as expensive and not always reliable for damages to be repaid.

2.4.1.8. Orontes River Basin (Lebanon)

In 2020, the Ministry of Agriculture in Lebanon launched the Lebanon National Agriculture Strategy (NAS) for the period of 2020 to 2025. The NAS was developed to address the key priorities of the agrifood sector. One of the significant pillars of the NAS is focused on enhancing the enabling institutional environment. This pillar aims to create favorable conditions for the development of agricultural insurance to mitigate the adverse effects of natural disasters on the agricultural sector. As part of the NAS, efforts are made to provide access to adapted and affordable financial products such as insurance.

2.5. Monitoring and enforcement

2.5.1. What approaches, technologies, and infrastructure are used to monitor water availability and supplies within the basin?

Note any significant gaps or limitations in monitoring systems.

2.5.1.1. Júcar River Basin (Spain)

The Automatic Hydrological Information System (SAIH) constitutes a network of collection and processing of precipitation data and control of the circulating flows and surface water resources (reservoir levels, channels and canals, gate positions, etc.), which covers the territory assigned to the Júcar Hydrographic Confederation. The SAIH of the Júcar was the first to be implemented in Spain and has been in operation since the end of 1989.

The main objective of the system is to achieve a better management of water resources and control in extreme situations such as flood events and drought periods. According to these objectives, this system allows a real-time monitoring of all meteorological, hydrological-hydraulic, alarm and state variables of sensors and gates in the basin and maintain a historical database sufficiently complete and correct so that it can be used at the level of basin management, hydrological planning and dissemination of information.

The tele-measurement network of the SAIH of the Júcar Hydrographic Confederation is constantly expanding and improving, and currently consists of about 200 data collection points. The most important points have several communication channels to ensure communication in case of a possible failure of the network. The data captured by the different sensors and alarms are recorded in the so-called control points that transmit their information via radio and/or satellite to the Basin Processing Center located at the headquarters of the Confederation in Valencia, where the information received is analyzed and exploited.The data, updated every 5 minutes, is a reliable and contrasted resource for the improved management of the system.

2.5.1.2. Nitra River Basin (Slovakia)

SHMÚ is responsible for monitoring water quantity in its monitoring network according to the Water Act No. 364/2004 Coll. and in line with the Program for Water Monitoring of the Slovak Republic 2022 - 2027. Water level and temperatures are available in real time online, while extended information on the hydrological situation including flows at selected stations is given every morning at 6:00 AM. SHMÚ monitors hydrological drought index beside meteorological drought. The hydrological drought situation is available online in real time and is estimated as daily or monthly mean flows relative to reference levels (1961-2000).

The Water Policy Concept 2030 aims at improving water monitoring so that it would reflect new challenges such as climate change, extreme weather events, pollution, river network fragmentation, biodiversity loss, invasive species, etc. The objectives include implementation of innovative monitoring approaches (satellite imagery, remote sensing). Furthermore, the objectives include implementing or improving of numerical and biophysical modeling of climate change impacts on runoff, water quality, and biotic and abiotic processes. It also aims at connecting the different monitoring frameworks within the water other relevant policies such as biodiversity or adaptation strategies. According to the Water Policy Concept, the Ministry of Environment should also develop methodologies for defining so called ecological flows, which would consider the different water users´demands in times of water scarcity so that the biological life would not be threatened. The Ministry will also coordinate developing methodologies for the minimum levels of groundwater to ensure sustainable use.

2.5.1.3. Reno River Basin (Italy)

For irrigation use, monitoring of water availability in relation to extraction is regulated by the regional decree n. 2295 of 2021, which is the result of the transposition of the European Community and national legislation and in particular of the Decree of the MIPAAF (Ministry of Agriculture, Food and Forests) of 2015. This decree presents several tools used to measure the flows of the rivers in relation to the extraction, with a list of additional information: a list of all the necessary descriptions required to monitor these tools (functioning, parameters, accuracy, installation, data collection, data transmission); instructions about the systematic inspections required to verify the correct functioning of the tools (inspections must be done in order to recalibrate parameters); information on minimum requirements for measurement systems, data collection and transmission, which depend on the relevance of the withdrawal site (in the most restricting scenario, the measurement must be transmitted daily).

In general, the water availability of the Reno River and the other regional rivers is monitored by ARPAE - SIMC (Hydro-weather-climate Service) with the support of an external company called CAE. The monitoring network consists of hydrometric stations connected to a radio network.

2.5.1.4. Tympaki River Basin (Greece)

The hydrological stations "Tympaki airport" and "Tympaki A3" have daily data on conductivity, water temperature, water level and water depth, available online on the website of the Water Directorate of the Decentralized Administration of Crete (WDC).

The hydrological parameters of the Faneromeni reservoir and related daily data (e.g. water temperature, dump volume, water depth, water level) of the dam are publicly accessible online on the website of the Water Directorate of the Decentralized Administration of Crete. The Faneromeni reservoir is used for irrigation purposes and has an automated water capacity calculation system which gives real-time available water reserves. At the same time, there are classic-type (mechanical) water level meters installed inside the dam.

Groundwater levels are also monitored by the Hellenic Survey of Geology & Mineral Exploration (EAGME) in observation wells (linked to the National Monitoring System)

The Local Land Reclamation Organisation "TOEV of A' Zone of Messara" monitors a number of boreholes used for irrigation water supply. The amount of available water from boreholes is being calculated according to the hydrogeological characteristics of each borehole and water level measurements.

DEYA Faistou has prepared a study on telemetry and is trying to find a funding source in order to be able to monitor water availability and supplies for domestic water use.

2.5.1.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

In the Maure – Mauri River basin has a network of hydrological stations that monitor the streamflow and water quality of the river and its tributaries. There are 40 stations in the basin, operated by different institutions such as Meteorological Services [SENAMHI-Peru/Bolivia], Especial Project Tacna [PET], ministry of environment and water [MMAyA-Bolivia], and National Water authority [ANA-Peru]. The stations are located at strategic points along the river, such as Vilacota in the upper site near the volcaninc region of the system, Chuapalca near the intake system for the hydraulic transfer to the pacific region, Frontera in the border between Bolivia and Peru, Abaroa Mauri and Calacoto in the confluence between Mauri and Desaguadero river. The stations collect data on discharge, water level, precipitation, temperature, and water chemistry, not all with the complete set of variables, there are specific stations for each variable [p.e, precipitation has 24 stations, for streamflow 8 stations]. The data is used for developing a hydrological model for the basin, as well as for planning and management purposes, the current period available used by the local managers is from 1965 to 2020. However, some of the stations are in poor condition or need maintenance, and some of the data is incomplete or inaccurate[16] which are the most challenging part to use datasets from them, big efforts have been carried out by the local institutions to curate the data. Therefore, there is a need to improve the quality and availability of the data for better decision making.

2.5.1.6. Mahanadi River Basin (India)

Hydrological monitoring is being done by the respective office of the Central Water Commission for the flows in the rivers and tributaries of Mahanadi (like other river basins). The CWC maintains 39 gauge-discharge sites in the basin. In 13 of these stations, sediment observations are also made. The Central Water Commission maintain 4 flood forecasting stations in the basin. In addition, the State Water Resources Departments monitor inflows into reservoirs, outflows from the reservoirs (through spillways) and release of water for various uses through canals and pipelines. They also prepare the reservoir mass balance for all major and medium reservoirs in the basin with a periodicity of 10 days. In addition, gauge-discharge data are available for 34 sites established by the State Governments.

2.5.1.7. Murray-Darling Basin (Australia)

As stated, technologies include storage gauges and monitoring coupled to expected inflows/demand to establish water availability going forward and make allocation decisions. These allocations are typically assessed and updated every two weeks during the water year (i.e. opening in April and closing again around the following March annually) and are never reduced or wound-back once announced. Allocations are determined using a calculation based on flow and demand within a set framework.

2.5.1.8. Orontes River Basin (Lebanon)

At present, Lebanon has a total of 136 meteorological stations and 138 hydrometric stations distributed across the country. These stations are managed by various organizations, including the Lebanese Meteorological Service, the Litani River Authority (LRA), and the Lebanese Agricultural Research Institute. However, it is important to note that there is currently no integrated system in place that connects these stations into a unified Hydrometric Information System (IHIS). As a result, the data collected from these stations may not be efficiently shared or coordinated, limiting the effectiveness of monitoring, and managing water resources across Lebanon.

2.5.2. What approaches, technologies, and infrastructure are used to monitor water extraction and use within the basin?

Instruction to note any situations where use is not actively monitored, reliant on self reported information, etc.

2.5.2.1. Júcar River Basin (Spain)

Water users, associated in Irrigation Communities, are required to report the water abstractions to the CHJ in water bodies that have been declared in bad quantitative status.

2.5.2.2. Nitra River Basin (Slovakia)

Water users who were granted permit are obliged to measure and report the amount of water abstracted to SHMÚ once a year using a certified device. If the user does not choose a device, the SVP as the water manager is supposed to do so. SHMÚ is in charge of processing the data and compiling an annual report that gives and overview of the monitored parameters including surface water quantity. The water manager can carry out a control and forward the infringement to the water authority such as the district authority to process the case. To our knowledge, however, there is no sophisticated system in place for monitoring water extraction and use.

2.5.2.3. Reno River Basin (Italy)

Monitoring of water extraction and use within the basin is managed by Arpae (State property area). The monitoring tools depend on the type of extraction under concession. For monitoring of potable water extraction, a specific joint system between ATERSIR and Emilia-Romagna Region updates data concerning extraction and consumption. Data monitoring is not in real time; data is mainly updated the following year, however in some specific cases, such as strategic hubs like Casalecchio Lock, it is updated more often.

For irrigation use, monitoring of water extraction is regulated by the regional decree n. 2295 of 2021, which is the result of the transposition of the European Community and national legislation and in particular of the Decree of the MIPAAF (Ministry of Agriculture, Food and Forests) of 2015. The provisions on the quantification of water volumes of irrigation use are the following: 1) water boards coordinated by ANBI take care of measurement, transmission, periodical update of volumes used for collective irrigation and they transmit the information to the national system SIGRIAN; 2) water boards must have specific equipment for the correct required measurement, and if the installation of these tools is not possible, they must the software for irrigation advice, IRRINET; they must follow a precise timing for data transmission; measurement si not required if IRRINET is used or in case of technical or economical non-feasibility.

2.5.2.4. Tympaki River Basin (Greece)

Irrigation water: The provision and supply of irrigation water in the Tympaki basin is under the responsibility of the Land Reclamation Organisations “TOEV of A’ Zone of Messara”. Irrigation water is obtained from the Faneromeni Reservoir and the boreholes of the TOEV. To monitor the amount of water that can be extracted from the Faneromeni reservoir, electronic hydrometers have been installed and are checked at regular intervals by the Local Land Reclamation Organisations TOEVs (there are 3 TOEVs that get irrigation water from the Faneromeni Reservoir, including the “TOEV of A’ Zone of Messara” which is responsible for the Tympaki basin). Each TOEV is responsible for the correct operation of its own hydrometer, while the overall supervision of the dam's water management is carried out by the Faneromeni Dam Committee. To monitor the use of water throughout the irrigation network the “TOEV of Zone A’ of Messara” has installed water meters for all users, while an automated water management system is in operation in all boreholes. The system ensures that each borehole is not operated when water level falls below the safe operating thresholds.

Domestic water: The provision and supply of irrigation water in the Tympaki basin is under the responsibility of the DEYA Faistou. The water used is monitored through water meters, available in every connection. DEYA Faistou has prepared a study on telemetry and is trying to find a funding source in order to be able to automatically monitor water extraction and use. The water-meters currently used are conventional and there is a Funding Decision in place to purchase digital water-meters (funding source Ministry of Development and Investment, Operational Program "Transport Infrastructure, Environment and Sustainable Development 2014-2020").

2.5.2.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

The Pacific and Maure – Mauri regions of the system have infrastructure to monitor water extraction, in the case of the pacific there are a complete set of stations for the most important systems for the user from agriculture for surface and groundwater sources, the network is generally managed by PET and each water use is responsible to report the water volume used every month. In the case of Maure, there are stations in the channels after the intakes in the areas of Kovire [transfer to users from population and mining sector] and Chuapalca/Uchusuma intakes to the Tacna region for agriculture user. The information is available in times series at monthly level from 1965 to 201517.

In the case of the Desaguadero region, there is no infrastructure to monitor water extraction, there are estimation run by simulation about the volumes diverted by the irrigation systems, and the yearly evaluation reported to AAPS for industrial, and water consumption18.

2.5.2.6. Mahanadi River Basin (India)

As regards irrigation, only water release through main canals and pipelines is measured through manual flow measuring devices. In the case of urban water supply, there is monitoring of the supplies at the aggregate level. However, there is no monitoring of use at the individual level that covers all the users. Only the bulk water use is measured through water meters. In the case of rural water supplies, there is no monitoring of either supplies or use. There is no monitoring of water use by individual farmers. In the case of groundwater supplies, there is no monitoring done for water withdrawals by the hundreds of thousands of individual farmers.

2.5.2.7. Murray-Darling Basin (Australia)

Mostly extraction and use is monitored via in-river system flow gauges and on-farm meters at the point of off-take from the delivery systems (e.g. direct river pumping or supply channels from local storages). Meters may be connected via telemetry to central systems or read by IIO staff on a regular basis.

2.5.2.8. Orontes River Basin (Lebanon)

Water monitoring equipment used are quality meters and flow meters. As for data storage, the HYDATA database used for storing water quantity data for all Lebanese gauging stations.

2.5.3. What procedures and processes, if any, are in place to ensure the accuracy and reliability of data relating to the monitoring of water extraction, use, and availability?

Do they have staff for controlling the basin? Do they have material resources (cars, etc.)? Is the staff trained? How regular are the inspections (monthly, yearly, other)? Do they target the largest water uses/users (agriculture, large farms)? Are they publishing data of offenders? Are the inspections announced to users? Identify key barriers and challenges.

2.5.3.1. Júcar River Basin (Spain)

Resources are lacking for most of this activities.

2.5.3.2. Nitra River Basin (Slovakia)

Dependent on structural funds. While organizations have some trained staff and material, there is in general lack of resources. They are targeting largest water users and mostly have no capacity to control all the small ones. The inspections´ frequency depends on the issues that occurred. Daily inspections can occur, but again the resources mentioned above are the limiting factor. The data of the offenders are likely not published. RBMP mentions who did or did not fulfil their responsibilities (e.g. in relation to BAT technologies).
Key barriers are inadequate personal capacities, financial resources, low societal awareness and often the business approach wins (developers).

2.5.3.3. Reno River Basin (Italy)

For irrigation use, procedures and processes to ensure the accuracy and reliability of data are regulated by the regional decree n. 2295 of 2021. All data is transmitted to SIGRIAN and validated by Emilia-Romagna Region. The validation process operated by SIGRIAN must treat data following these three principles: completeness, consistency, adequacy. Data are then validated and other characteristics are taken into consideration: periodicity and temporal validity of the validation, territorial competence and scale.

2.5.3.4. Tympaki River Basin (Greece)

Irrigation water: The provision and supply of irrigation water in the Tympaki basin is under the responsibility of the Land Reclamation Organisations "TOEV of A' Zone of Messara". Irrigation water is obtained from the Faneromeni Reservoir and the boreholes of the TOEV. To amount of water that can be extracted from the Faneromeni reservoir is monitored via, electronic hydrometers. These are checked at regular intervals by the Local Land Reclamation Organisations TOEVs in order to ensure reliability and detect any problems in due time. The water meters in the groundwater abstraction wells are also monitored and inspected at frequent intervals, as well as the water supply networks to detect any leakage. The TOEV of A' Zone of Messara is in direct and regular contact with its end-users/farmers who immediately report any observed problems, such as low water transparency, increased sediments in the water, reduced pressure, etc. This direct feedback loop also safeguards timely response (e.g. any observed sand in the water by the farmers would alert the TOEV that the groundwater level has declined).

Domestic water: The provision and supply of irrigation water in the Tympaki basin is under the responsibility of the DEYA Faistou. DEYA performs regular inspections on their water supply network to detect and repair any malfunctions, leakages, etc. The water used is monitored through water meters, available in every connection. The users are sensitized to promptly and timely report all failures, water supply interruptions, etc., via the DEYA website or their call center. This direct feedback loop also safeguards timely response in case e.g. of defective water meters.

2.5.3.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

The data which monitor the water availability and extractions in the basin has share under a binational evaluation which was in charge to make statistical analysis of the time series check spatial and temporal correlation to identify outliers, remove them and complete the time series to use to estimate the total water availability of the system [Maure - Mauri region] through hydrology modelling. The hydrological model for Maure - Mauri basin was developed using the WEAP platform and the soil moisture balance method (Yates, 1996). This method simulates the water balance in each hydrological response unit (HRU), which are sub-basins defined by topography, land use, and soil type. The model considers the inputs (precipitation and groundwater recharge), the outputs (evapotranspiration, surface runoff, and groundwater discharge), and the storage (soil moisture and groundwater). The hydrological model was calibrated and validated using the observed flows at different points along the Maure-Mauri River. The calibration was done by adjusting the parameters of the model to minimize the error between simulated and observed flows. The validation was done by comparing the simulated flows with independent observed flows that were not used in the calibration. The model performance was evaluated using statistical indicators such as Nash-Sutcliffe efficiency (NSE), coefficient of determination (R2), and percent bias (PBIAS)19.

2.5.3.6. Mahanadi River Basin (India)

There are no mechanisms in place to ensure the accuracy and reliability of the data relating to water extraction, use and availability.

2.5.3.7. Murray-Darling Basin (Australia)

These roles are mainly performed by staff at the MDBA.

2.5.3.8. Orontes River Basin (Lebanon)

There is a need for institutional and capacity building in the water and wastewater sector, including training of staff on environmental safeguards and compliance monitoring. The final draft of the 2020 National Water Sector Strategy (NWSS) recognizes the challenges and recommends strengthening the management structure of the RWEs, including the recruitment of qualified staff and reviewing organizational decrees.

2.5.4. Have there been any reported or known infringements of rules, rights, or regulations relating to the use, extraction, or allocation of water within the basin?

2.5.4.1. Júcar River Basin (Spain)

In the past, illegal groundwater pumping and surface water diversion for irrigation, especially in La Mancha Oriental aquifer have caused depletion of water resources and damages to natural ecosystems.

2.5.4.2. Nitra River Basin (Slovakia)

No known infringements reported to our knowledge.

2.5.4.3. Reno River Basin (Italy)

The main rule concerns the so-called DMV (minimum vital flow) of the river, which represents the minimum quantity of water necessary to safeguard the overall characteristics of the river. if the flow of the river in a certain area is under the DMV, withdrawals are prohibited, if the flow is near that threshold, withdrawals are limited.

No infringement of this rule has been reported for the Reno RB.

In specific circumstances, a derogation of this rule can be applied.

2.5.4.4. Tympaki River Basin (Greece)

Yes, from time to time. These are registered by Water Directorate of the Decentralised Administration of Crete (WDC) and mainly concern the compliance with the water use licenses. Penalties and fines are accordingly applied.

2.5.4.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

The system is a transboundary water region shared by Bolivia, Peru, and Chile, which requires a coordinated and integrated management approach. However, there are some challenges and gaps in the governance and institutional framework of the system, such as lack of harmonized norms and standards, weak enforcement and compliance mechanisms, insufficient coordination and cooperation among different levels and sectors, limited stakeholder participation and information sharing, and inadequate financial resources. These factors may lead to potential or actual infringements of water rules, rights, or regulations in the system, affecting its sustainability and quality.

In the bination master plan between Bolivia and Peru there are rules of volumes for extraction in general to each country [10 m3/s for each country], however this volume has no shared monitoring process which may help to identify in which time and place there are infringements.

2.5.4.6. Mahanadi River Basin (India)

There is no reported case of infringement of rules with regard to water use. The problem in the case of Mahanadi is that no rules regarding water allocation are in place till date and because of this, the demand for a tribunal has been made by the lower riparian state of Odisha. However, this doesn't mean that there are no conflicts. There are conflicts arising out of competing uses—industry vs fisheries, agriculture vs industry etc.

2.5.4.7. Murray-Darling Basin (Australia)

Yes, plenty. See for example these recent examples as reported in the news:

- https://www.theguardian.com/australia-news/2023/mar/31/prominent-nsw-irrigators-fined-60000-for-breaching-water-licence-conditions
- https://www.theguardian.com/australia-news/2023/apr/05/riverina-irrigator-fined-150000-for-illegally-extracting-11m-of-groundwater
- https://www.abc.net.au/news/rural/2021-06-08/calls-for-tougher-penalties-for-unlawful-water-take/100116668
- https://www.abc.net.au/news/rural/2021-04-22/irrigator-compliance-concerns/100086068
- And the general NRAR website: https://www.dpie.nsw.gov.au/water/licensing-and-trade/compliance

The issue remains what is happening in other states beyond NSW? They have less resources in the area, and lower levels of reporting publicly or like the NRAR, so still a large challenge for the MDB.

2.5.4.8. Orontes River Basin (Lebanon)

It is challenging to identify or prove the infringements of regulations related to water extraction/use in the Orontes River Basin because there is no enough monitoring.

2.5.5. What sanctions and penalties are applied in the event of a violation of rules, rights, or regulations relating to the use, extraction, or allocation of water within the basin?

Instruction to note whether there are differences between sanctions defined in policy and those implemented in practice.

2.5.5.1. Júcar River Basin (Spain)

There are fines for illegal groundwater pumping and surface water diversion for irrigation, which can range from 300 to 600,000 euros depending on the severity and recurrence of the offense. Suspension or revocation of water concessions or authorizations for non-compliance with ecological flows and environmental objectives. Administrative or judicial actions for water quality impairment due to urban, industrial and agricultural pollution loads.

However, these sanctions and penalties are often not effective or enforced due to lack of instruments for water management and law enforcement, as well as political and social resistance.

2.5.5.2. Nitra River Basin (Slovakia)

The fines and rules are defined in the Act No. 364/2004 Coll.

2.5.5.3. Reno River Basin (Italy)

In the event of a violation of rules, some sanctions are applied. One concerns the hydrological state of rivers and the regulation of withdrawals in drought conditions: withdrawals operations when the hydrological state of rivers is under the DMV (minimum vital flow) are punished through the sanctions provided by the Royal Decree n. 1775 of 1933. DMV also serves as a tool of autoregulation and reporting of drought conditions and is not necessarily linked to sanctions.

Other abusive withdrawals, non-observance of the obligations and the prescription of the disciplinary are punished by the administrative sanctions of the State property, which are provided by Royal Decree n. 1775 of 1933 and the law n. 689 of 1981 and the regional law n. 21 of 1984.
No sanctions have been reported for the Reno RB.

2.5.5.4. Tympaki River Basin (Greece)

The Water Directorate of the Decentralized Administration of Crete (WDC) and the Department of Water Economy of the Region of Crete (namely the so-called Environmental Quality Control Bodies – KEPE) carry out self-proclaimed inspections and controls or after a named justified complaint, for violations of the provisions of water use licenses or for illegal wells, according to the Joint Ministerial Decision 146896/14. In the case a violation is found, the expenses for carrying out the controls burden the user/violator. Furthermore, the following fines apply (both within the Law and in practice):

- A fine of 3,000-10,000 euros applies in the case someone has implemented a water abstraction/exploitation related work (e.g. opening a well) without having a valid permit to execute this work. The fine is imposed both on the owner as well as to the technical person responsible for the execution of the works.
- A fine of 3,000-5,000 euros applies in the case someone is abstracting water from a source without having a valid water use license for this specific purpose/source
- A fine of 500-5,000 euros applies in the case a licensed water user is violating the terms of use and obligations

In the case of non-compliance the WDC can further revoke a water license and shut down the abstraction infrastructure/well.

2.5.5.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

In the case of the Pacific Region [Caplin basin] with the regulation and monitoring made by PET and the regional secretary of ANA Peru in Tacna, there are mechanisms to penalize infringements, this is done by the evaluation every three months by the Local Water Administrator [ALA].

In the case of the region in the transboundary region of the system there is no penalization of infringements because of the requirement of binational consensus about all the specific water extraction and the lack of the monitoring of the extraction previously explained.

2.5.5.6. Mahanadi River Basin (India)

Only inter-state water disputes will have to be adjudicated through the newly formed Mahanadi Water Disputes Tribunal. The tribunal came into existence only three years ago and is yet to award 'water shares' for the basin states. In the case of irrigation water, the Water Resources Department can impose penalty on those who illegally divert water from canals, rivers and reservoirs.

In the case of pollution, the State Pollution Control Board can issue notices to the polluters for compliance of pollution control norms and in case of non-compliance, can file a case in the High Court of the respective state for penal action under the Pollution (Prevention & Control) Act 1974 and the environmental protection Act of 1986.

2.5.5.7. Murray-Darling Basin (Australia)

This is very complex, and not straightforward to provide here given the scope, scale and nature of regulatory requirements and violation opportunities. They differ by each Basin state, and cover many different infringements based on right, reliability, location conditions of use etc. In general, penalties will include substantial and punitive monetary fines, and/or jail time if the offence allows for and warrants such punishment. It is a rare occasion though, where water users are jailed for illegal actions. As an example of recent penalty changes see here.

2.5.5.8. Orontes River Basin (Lebanon)

A warning is issued or a ticket, and in some cases the water supply is disconnected.

2.5.6. In what ways, if any, are digital technologies being used within the basin to strengthen monitoring of water extractions, use, and availability?

Instruction to note any learnings about successful or unsuccessful use of digital tech.

2.5.6.1. Júcar River Basin (Spain)

The use of remote sensing is applied to monitor the use of groundwater in regions such as La mancha Oriental. The eGROUNDWATER project aims at supporting sustainable participatory groundwater management in the Mediterranean regions through the design, testing and assessment of enhanced information systems, combining modelling, mobile applications and participatory approaches.

2.5.6.2. Nitra River Basin (Slovakia)

The use of digital technologies in monitoring is most likely very limited.

2.5.6.3. Reno River Basin (Italy)

As for digital technologies, the Italian Public Property Agency platform and ARPAE modelling processes must be considered. In general, the Emilia-Romagna Region employs WEI+ (water exploitation index plus) to compare the percentage of water use and renewable freshwater resources in a given time and place. Unfortunately, this index is not suitable for the Reno basin, since its waterways naturally end up in water shortage during summertime. In addition, this area faces a lack of a global water balance plan to fully regulate the management of water resources, because some hillside reservoirs are administered by private consortia. Therefore, in river contracts there are joined water balance plans.

2.5.6.4. Tympaki River Basin (Greece)

The "TOEV of Zone A' of Messara" has initiated the installation of a telemetric management system for the entire irrigation network of the organization. The project has been licensed and approved and implementation is expected to start soon.

DEYA Faistou has prepared a study on telemetry and is trying to find a funding source in order to be able to monitor water availability, extraction and use. The water-meters used are conventional and there is a Funding Decision in place to purchase digital water-meters (funding source Ministry of Development and Investment, Operational Program "Transport Infrastructure, Environment and Sustainable Development 2014-2020").

The WDC has automatic telemetric hydrological stations, including the monitoring of the Faneromeni Reservoirs (daily measurements are available online).

2.5.6.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

he evaluation and diagnostic about the water management implementation in the regional system of TDPS from 2022, give some details about digital technologies area been used by the regional institutions in Bolivia and Peru, such as:

A geographic information system (GIS) that integrates data from different sources and allows the visualization and analysis of spatial information on water resources, land use, biodiversity, and socio-economic indicators22. There is information about geolocation of the project made by the governments under the support of UNDP and GEF and pilot implementations of action under water management diagnostic.

A hydrological model that simulates the water balance and flow dynamics of the system, using data from meteorological stations, gauging stations, satellite images, and other sources. There are two hydrological models one for jurisdiction of Peru and another for Bolivian jurisdiction in SWAT. There is only one hydrological model with bination consensus which is compiled in WEAP, none of the models are publicly available SWAT models report are available online [https://girh-tdps.com/].

A database that stores and manages the information collected from different sources and provides access to users through a web platform. There is an online report about water user in all TDPS system no available GIS data [https://girh-tdps.com/].

As previously mentioned, their technologies which mainly area focused online repositories however none has a goal to support monitoring of water extraction.

2.5.6.6. Mahanadi River Basin (India)

There is no use of digital technologies for monitoring the use of water in any of the sectors in the basin.

2.5.6.7. Murray-Darling Basin (Australia)

There are some recent developments in the use of satellite monitoring of farm water storages, delivery systems and river flows (i.e. gauges) to detect and flag suspicious extractions or offtakes of water across the landscape, in conjunction with satellite uploads of metering data via telemetry to report when water is used locally. Innovation in the area of compliance and monitoring is undertaken by the Inspector-General of Water Compliance office (IGWC, 2023), which was split away from the MDBA in 2022 to create a separate and distanced compliance agency to dispel concerns over the MDBA 'marking its' own homework'. Additional digital innovations include algorithms and apps designed to enforce extraction and compliance outcomes amongst water users, as well as drone technology use.

2.5.6.8. Orontes River Basin (Lebanon)

NA

2.5.7. In what ways, if any, are citizens involved in the process of monitoring of water extractions, use, and availability?

Instruction to note any examples of citizen science or participation.

2.5.7.1. Júcar River Basin (Spain)

The CHJ has implemented three levels of public participation in hydrological planning: public information, public consultation and active participation. Public information aims to inform citizens about their rights and provide them with relevant documentation. Public consultation allows citizens to express their opinions and influence decision-making. Active participation involves citizens in deliberating and solving problems related to hydrological planning.

The eGROUNDWATER project aims to improve sustainable, participatory groundwater management in the Mediterranean region by developing and testing Enhanced Information Systems (EIS) that integrate **citizen science** and information and communication technology (ICT) tools. A key component of the EIS is a **mobile app** that will allow farmers and other groundwater users to report groundwater levels in their wells and the amount of water used for irrigation and other purposes. At the same time, the app will provide users with information about the state of the aquifer and recommendations for sustainable water use (for example, short-term and seasonal predictions of irrigation water needs).

The eGROUNDWATER app has the potential to be a valuable tool for improving the sustainable use and management of aquifers in the Mediterranean region. By gathering real-time data from a wide range of users, the app will help to create a more complete and accurate picture of groundwater conditions and usage. Policymakers and resource managers can use this information to make informed decisions about the allocation and use of water resources. It can also help to identify potential problems and areas where conservation efforts may be needed.

The development of an app that meets the needs of the users required first to understand their perspectives and experiences related to the groundwater body. eGROUNDWATER has organized interviews and meetings in each case study, including one in the Jucar River Basin, to characterize the vision of the different agents on the groundwater bodies, and to try to build a collective framing of the current groundwater status and use in the area. On these meetings, the users identified lack of information about the aquifer as a critical issue to solve in order to advance towards a sustainable management of the resource.

In addition to providing valuable data and information, the eGROUNDWATER app has the potential to engage and educate farmers and other users about the importance of sustainable water management. The app can foster a sense of ownership and responsibility for the aquifer's health among users, as it offers personalized feedback and information about the use of water and the aquifer’s health. This, in turn, could lead to more responsible water use practices and help to preserve groundwater resources for the long-term.

2.5.7.2. Nitra River Basin (Slovakia)

Citizens and activists are more often involved in monitoring the water quality, especially in a case of pollution. Citizens that know of water extraction infringement may report that to the respective authority, however, no register with information on how often this happens is available.

2.5.7.3. Reno River Basin (Italy)

Citizens are involved in these processes through Citizen Science, an approach where scientific research becomes a factor of inclusion, participation and "democratization" of knowledge, for the benefit of the population.

Through the publication of open data resulting from these projects, together with the active involvement of the population, Citizen Science becomes an important opportunity for partnership between institutions and citizens, in order to propose and develop shared solutions regarding problems and critical issues.

Considering the potential of Citizen Science projects both for the community and for policy making purposes, the Digital Agenda of Emilia-Romagna has launched the Citizer Science initiative in collaboration with ART-ER Scpa, within the challenge n. 1 of the 2020-2025 programming of the Data Valley Common Good strategy, "Data for a widespread intelligence on the territory".

The aim of the project is to promote the dissemination and growth of the number of Citizen Science practices in the regional territory. The Framework and all Citizer Science projects are available on the website of the Digital Agenda of Emilia-Romagna https://digitale.regione.emilia-romagna.it/citizer-science.

These participatory processes are particularly useful for the development of projects and initiatives concerning water.

An example is the participatory process RIVER CONTRACT "BOLOGNA CITY OF WATERS", which, at the moment, led to the elaboration of a draft of an action program.

One of the presented actions provides "Pilot implementation of the urban and environmental regeneration project” through "Definition of hydraulic-environmental guidelines for the intervention and maintenance of the Navile Canal and involvement of citizens in the collection of environmental information (Citizen Science)".

The Navile canal was primarily a navigable canal and currently serves as a rainwater drainage route and a vector for irrigation water.

These functions have led and still lead to an environmental management of the watercourse based on the containment of the development of aquatic and riparian vegetation and more generally to limit its ecological and morphological evolution, in the past, to allow navigation, and currently to maximize its hydraulic functionality. The poor quality of the water flowing into the canal also does not create the conditions for maintaining a sufficient overall ecological quality.

Despite this, the canal has ecological and landscape potential of interest that, if adequately enhanced, can allow an adequate ecological functionality and a perceptual pleasantness for the users of the cycle and pedestrian path that flanks it.
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The action therefore envisages carrying out the following activities:

- define together with the competent bodies the methods of management and ecological requalification of the canal to ensure an adequate ecological status and hydraulic safety conditions
- create an Observatory of citizens who monitor and control ("adopt") the Navile channel
- develop methodologies for the control of the conditions of the channel ecosystem through the active participation of citizens (Citizen Science) in conjunction with the bodies in charge and to start experimental monitoring.

2.5.7.4. Tympaki River Basin (Greece)

Within the 1st revision of the approved RBMP for Crete the measure M13B0502 “Electronic annual recording of measurements of surface and groundwater withdrawals” was established. This measure concerns development of an electronic application in which users will directly complete the recorded water abstraction for surface and ground water. Electronic annual registration is mandatory for all abstraction volumes of more than 3,650 m3 per year. Each user has to report electronically the abstracted volume within the first ten days of November of each year.

In Crete this measure is not applied yet. Instead the Local Land Reclamation Organisations (TOEVs) monitor the abstractions. Furthemore, they are informed by each user directly about any problem or any disruption of the network, as well as about the the quality and the quantity of the water that is provided to the users/farmers.The TOEV of A’ Zone of Messara pursue the direct and regular contact and the interaction and involvement of its end-users/farmers, who immediately report any observed problems, such as low water transparency, increased sediments in the water, reduced pressure, etc. This direct feedback loop also safeguards timely response (e.g. any observed sand in the water by the farmers would alert the TOEV that the groundwater level has declined).

2.5.7.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

The surveys and reviews we make indicate that citizen participation in water monitoring in the TDPS system is limited and not well documented and in the case of the system for the project there is no involvement of citizens in the monitoring process yet. However, some possible ways to involve citizens are suggested, such as environmental education, the use of social networks and learning international good practices.

2.5.7.6. Mahanadi River Basin (India)

In the Mahanadi basin, citizens are not involved in the process of monitoring water availability and water abstraction. As a matter of fact, there is no river basin in the country where the process of citizen involvement in water resource and use monitoring is institutionalized.

2.5.7.7. Murray-Darling Basin (Australia)

Citizens are not really formally involved in these activities. While some citizens act as local monitors, state water departments, irrigation infrastructure operators, and the MDBA take lead roles in monitoring water extraction and use, and signaling availability.

2.5.7.8. Orontes River Basin (Lebanon)

NA

3. Nature-based solutions (NbS) for water storage

3.1. Status

Description of policies, instruments, authorities and funding opportunities for NbS and how they are implemented into practice.

Excursus: NbS are multi-functional measures that in the context of water aim to protect and manage water resources and address water-related challenges by restoring or maintaining ecosystems as well as natural features and characteristics of water bodies using natural means and processes. Their focus is to enhance, as well as preserve, the water retention capacity of aquifers, soil, and ecosystems with a view to improve their status. NbS have the potential to provide multiple benefits, including the reduction risk of floods and droughts, water quality improvement, groundwater recharge and habitat improvement. The footnote provides a list of examples for NbS in different categories to better understand where NbS can be used and to get an overview what kind of measures are included.[i]

3.1.1. Which specific policies exist to promote the implementation of nature-based solutions (NbS) for water storage, including funding opportunities?

Describe policies to promote the implementation of nature-based solutions, including funding opportunities (such as subsidies, projects, other) and economic instruments (tariffs, PES, markets, others).

3.1.1.1. Júcar River Basin (Spain)

As described in the last planification cycle for the basin, NbS can be subsidized by CAP agro-environmental subsidies due to their positive environmental impact. The Biodiversity Strategy 2030 announced by the European Commission proposes new legislation and guidance on green public procurement, integrating criteria to encourage the adoption of nature-based solutions. In this context, the redevelopment of flood plains is of relevance, with the recovery of banks and meanders, and the restoration and extension of flood plains, the reversal of hydromorphological deterioration, and, in short, the application of nature-based solutions aimed at a certain renaturalisation of rivers.

3.1.1.2. Nitra River Basin (Slovakia)

Nature-based solutions for water storage, retention, and floods prevention are mentioned in the most important environmental strategies such as Greener Slovakia 2030 (Strategy of the environmental policy of the Slovak republic until 2030, National adaptation strategy (NAS), National adaptation plan for implementation of the NAS (NAP), Water Policy Concept of the Slovak republic for 2030 with an outlook to 2050 (Water Policy 2030), and Water Plan of Slovakia (2022 - 2027). Regarding the Water Policy 2030 "Nature-based solutions will be preferred wherever it is technically and economically possible, because they are a tool for the protection, sustainable management and restoration of natural or human-altered ecosystems, respond effectively and adaptively to social challenges, improve biodiversity and at the same time they provide benefits to people."

NbS can be subsidized by CAP agro-environmental subsidies due to their positive environmental impact. Currently, the legislative framework for the period 2023-2027 is being revised at the national level in Slovakia.

Water management sector relies on public financing, which has been insufficient for a long time. This resulted in a great financing/investment debt and is reflected in, for example, old infrastructure and non-satisfactory state of the water reservoirs. The new Water Policy 2030 adopted in 2022 aims at setting up a long-term functioning and sustainable mechanism for financing the policy goals in general, as well as financing the NbS. One of the goals of the Water Policy 2030 is to support and coordinate financing restoration initiatives of flood prevention, adaptation, and water retention measures. Flood prevention plans should include finances allocated to restoration measures and improving the ecosystem condition, which should also make the public spaces more attractive. Another mechanism proposed is payments for ecosystem services. Giving preference to financing adaptation measures that support ecosystem functions accounting for climate change. Another objective is to set up financial mechanisms and policy instruments, as well as a structure of these mechanisms, which enables application of the various adaptation measures in the various parts of the water management, which should also motivate private sector to engage in such water management. International funding sources and projects such as Interreg or Living Rivers are promoting implementation of NbS.

3.1.1.3. Reno River Basin (Italy)

Subsidies. NbS can be subsidized by CAP agro-environmental subsidies due to their positive environmental impact. This is the case of NbS such as wetlands or Forested Infiltration Areas (FIA) where trees are planted in rows to facilitate infiltration to the aquifer—of increasing relevance in N Italy. In Italy, regionally adjusted CAP sub-measures, based on regional environmental characteristics, are integrated in the Regional Rural Development Programmes (Programma di Sviluppo Rurale - PSR), which can subsidize farmers that adopt low environmental impact or environmentally friendly production methods, such as the forestry component of FIA. EU's research funding (Horizon Programmes) and environment and climate action funding (LIFE) have funded also investments in innovative NbS, notably FIA (LIFE TRUST, LIFE AQUOR).

Implicit subsides also exist. In the case of Bosco Limite in Carmignano di Brenta (Padova Province), the largest FIA in Veneto region, the landowner is exempted to pay the Land Reclamation Board Tax (required to all the citizens benefitting the Land Reclamation Board activities for supporting the maintenance, management and monitoring costs of the territory). This is permitted by the PSR of the Veneto Region (see below).

Payment for ecosystem services (PES). An important recognition to NbS through managed aquifer recharge is the recent inclusion of this practice in the Veneto PSR 2014 – 2020 (Direzione AdG FEASR, 2018). Such initiative is providing loans and payments for landowners interested in implementing managed aquifer recharge (Intervention 4.4.2 “introduction of green infrastructures” and measure O33 “Experimentation and application of interventions that contribute to reducing nutrient release”). The Bosco Limite FIA receives, besides the tax discount from the region, a payment of 1200€/ha/year from the Brenta Land Reclamation Board (LRB, in Italian: Consorzio di Bonifica) for the aquifer recharge service provided. The municipalities (Carmignano di Brenta, Pozzoleone, Tezze and Vicenza) surroundings the area of “Bosco Limite” recognize the positive social and environmental impacts that the FIA provides to the community by supporting the recreational activities with a yearly payment of 640€/ha. In the Renana LRB, irrigators recently requested a PES to the Regione Emilia Romagna in exchange for the ecosystem services delivered by their drainage and irrigation supply activities, which maintain several ponds and wetlands surrounding the city of Bologna. The request led to a series of meetings between irrigators and the regional authorities and the PES is still being discussed (Pérez-Blanco and Sapino, 2022).

Tariffs. In Italy, the revenues from tariffs are not earmarked towards investments in the water sector. Yet, in the Piedmont Region a small part of the charges collected from water abstraction licences are re-invested in water management including grounwater protection. The Italian Decree 39/2015 (MATTM, 2015) allows the water utilities to include in water tariffs the costs related to sustainable catchment management interventions, such as NbS for water storage. Acque Spa, a water utility from Emilia Romagna has allocated since 1988 2% of its revenues (later increased to 3% in 2008 and then 4% in 2012) to the mountain towns where its treatment plants are located in order to indirectly support watershed protection (Leonardi, 2015).

3.1.1.4. Tympaki River Basin (Greece)

Nature-based solutions are promoted in the Flood Risk Management Plan of Crete (drafted according to the requirement of the EU Floods Directive), namely measure EL13_31_08 “Promotion of practices for reducing flood flows and retaining sediment transport, with an emphasis on the Natural Water Retention Measures (NWRM). Furthermore, the artificial aquifer recharge of groundwater bodies aiming at increasing the exploitable amount of groundwater, the underground storage of water, for future exploitation, the restoration of the hydrological balance that was disturbed due to overexploitation, and the improvement of the groundwater quality in case of degradation, is promoted in the River Basin Management Plan of Crete. More specifically, the following measures to control and license the artificial recharge of GWBs are included in the RBMP of Crete:

- M13B0601: Investigation of the conditions of application of artificial recharge of underground aquifers as a mean of quantitative enhancement and quality protection of GWBs, with a priority for GWBs with poor condition and treatment of salinity intrusion
- M13B0602: Establishment of a National Register of treated wastewater disposal sites (as per the JMD 145116/2011, GG 354/B/2011)
- M13S1001: Utilization of treated wastewater of WWTP of Heraklion for artificial recharge of aquifers not intended for human consumption
- M13S1401: Artificial recharge projects of basin Thrapsano - Nipiditou

In the Crete RBD (EL13), several artificial recharge projects have been carried out, with the most important ones at the area of the western Messara plain and at the GWB PORODES MYRTOU (EL1300124).There are several small-scale projects scattered around the island that support the local aquifers.

3.1.1.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

After a preliminary set of interviews to local partners of the project, it was not identified specific policies to promote NbS in the Bolivia or Peru, however from the evaluation of the national policies we can list a set of those which can allow integrate NbS into planning of actions for water recourses allocations and management.

3.1.1.6. Mahanadi River Basin (India)

No specific policies exist for promoting nature based solutions. However, there are several government programmes that provide funds for implementing nature based solutions like watershed management. Yet no clarity exists on where such programmes should be implemented and at what intensity or scale.

3.1.1.7. Orontes River Basin (Lebanon)

One of the pillars in the NAS (2020 – 2025) is “Improving climate change adaptation and sustainable management of agrifood systems and natural resources”. By 2025, the objective of the program is to enhance adaptation to climate change and sustainable management of natural resources, while increasing the use of low-carbon technologies and practices. Four programs are proposed, focusing on climate change adaptation, sustainable resource use, efficient irrigation water use (e.g. construction of hill lakes), and promoting renewable energy in agriculture.

3.1.2. How are NbS integrated into existing water management regulation and instruments?

Describe the regulatory status of NbS for water storage in the case study site.

3.1.2.1. Júcar River Basin (Spain)

Not clearly integrated within the existing water management regulation.

3.1.2.2. Nitra River Basin (Slovakia)

The above-mentioned policies and strategies relating to Nbs apply aso to Nitra RB. Because no specific and systemic payment or subsidy schemes are in place for financing NbS, the implementation is up to the Nitra self-governing region, other governmental institutions subordinate to the Ministry of Environment, and private actors. However, water storage, retention, and regulation are mostly mentioned in relation to the role of forests in water regulation. The Ministry of Agriculture and Rural Development of the Slovak Republic is responsible for managed forests, and there is an existing payment scheme for forest ecosystem services.

3.1.2.3. Reno River Basin (Italy)

Despite the increasing attention to the management of water scarcity with NbS for water storage, the Italian regulative and institutional framework is complex and prevents the implementation of economic instruments that directly support NbS for water storage (Pettenella et al., 2012; Santato et al., 2016). Rather, EU figures such as CAP agro-environmental schemes or pre-existing figures such as contracts between parties for the provision of ecosystem services (PES) are used. Notably, the Veneto Region has allowed in its PSR the payment to agents providing NbS water storage through managed aquifer recharge. A major limitation to the implementation of NbS for water storage is the use it or leave it/right of use approach, where the water right is provided on a yearly basis, meaning that any water voluntarily stored by a private user through NbS (FIA, wetlands) or water works (dam) automatically belongs to the public domain. This complicates the recovery of the water stored by a given user, and penalizes intertemporal allocations. Water banks and markets have great potential to maximize the value creation from NbS for water storage by means of reallocating the resource across space and time, but its application is limited by Italian law, which does not allow for intertemporal or spatial reallocations.

3.1.2.4. Tympaki River Basin (Greece)

Nature-based solutions are included as a measure in the Flood Risk Management Plan of Crete (drafted according to the requirement of the EU Floods Directive), namely measure EL13_31_08 “Promotion of practices for reducing flood flows and retaining sediment transport, with an emphasis on the Natural Water Retention Measures (NWRM). Furthermore, the artificial aquifer recharge of groundwater bodies aiming at increasing the exploitable amount of groundwater, the underground storage of water, for future exploitation, the restoration of the hydrological balance that was disturbed due to overexploitation, and the improvement of the groundwater quality in case of degradation, is included in specific measures (bundle of measures to control and license the artificial recharge of GWBs: M13B0601, M13B0602, M13S1001, M13S1401).

When it comes to the execution of artificial groundwater recharge projects using natural spring or surface water, in order to maintain the capacity of the groundwater water system and for the purpose of preventing its deterioration and/or enhancing its restoration, a license is required and is granted to the public, municipal or supervised entity that carries out the project, according to the provision of the Joint Ministerial Decision 146896/2014. The artificial groundwater recharge with treated wastewater, through surface filtration or directly through boreholes, is also subject to licensing according to the Joint Ministerial Decision 145116/2011 "Determining measures, conditions and procedures for the reuse of treated wastewater and other provisions” as modified and complemented by the JMD 191002/2013.

Environmental permit requirements also apply, while the water quality requirements/criteria are very strict.

3.1.2.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

In Peru there many regulations and policies which can integrate NbS in management planning frames. The Water Resources Law, enacted in 2009 that establishes the principles, norms, and institutions for the integrated and participatory management of water resources in Peru. The law recognizes the importance of ecosystem services for water provision and regulation, and creates mechanisms for financing conservation and restoration initiatives, such as water tariffs, compensation schemes and public-private partnerships. The National Strategy for Forests and Climate Change adopted in 2016 aims to reduce deforestation and forest degradation, enhance carbon stocks, and promote sustainable forest management in Peru. The strategy includes actions to implement NbS for water security, such as restoring degraded lands, protecting watersheds, and promoting agroforestry and silvopastoral system. The National Policy on Wetlands approved in 2018 seeks to conserve and restore wetlands as strategic ecosystems for water regulation, biodiversity conservation, climate change adaptation and mitigation, and human well-being. The policy establishes guidelines and instruments for the integrated management of wetlands, such as zoning plans, monitoring systems, incentive mechanisms, and participatory governance.

In the case of Bolivia, there are policies such us the Mother Earth Law enacted in 2012 recognizes the rights of nature and establishes a framework for the holistic and integrated management of natural resources and ecosystems in Bolivia. The law promotes the conservation and restoration of water sources, wetlands, forests, and other strategic ecosystems, but not under the concept of “environmental services” which disable the application of NbS in the country.

3.1.2.6. Mahanadi River Basin (India)

Nature based solutions are not integrated into existing water management approaches. These activities (conventional water management approaches and nature based solutions) are handled by different agencies with one not taking cognizance of the other.

3.1.2.7. Murray-Darling Basin (Australia)

This is a focus of the water sharing and planning process which is supposed to be reaching uniform status under the Basin Plan requirements, but is lagging significantly behind acceptable progress. The water sharing plans, when agreed and certified as acceptable, are aimed at providing a consistent means of recognizing and managing NbS issues into existing regulatory and management arrangements. Again, a main regulatory instrument in this space is the Basin Plan and its broad set of accountability and objective measures.

3.1.2.8. Orontes River Basin (Lebanon)

In the Orontes River Basin, there are no specific Nbs for water storage., aside from the Yammoune lake.

3.1.3. Which authorities/actors are responsible for and supporting the implementation of NbS for water storage?

Describe the main actors and their roles.

3.1.3.1. Júcar River Basin (Spain)

Empresa de Transformación Agraria S.A. , proyecto DINA-MAR

3.1.3.2. Nitra River Basin (Slovakia)

The most important actor for the implementation of NbS and water storage is the Ministry of the Environment of the Slovak Republic. The Slovak Water Management Company is also an important entity as the administrator of water courses, including the management of the Nitra river basin. Another important institution is the Water Research Institute, which is responsible for research activities in the field of water management at the national level. It is also necessary to mention other authorities/bodies with matching authority at the regional and local level - the district office in the regional headquarters in Trenčín and Nitra and other relevant district offices. The region is also part of the self-governing regions - Trenčín self-governing region and Nitra self-governing region.

3.1.3.3. Reno River Basin (Italy)

EU through the CAP and LIFE programmes; municipalities through PES; regions through implicit subsidies (reduced tariffs) and earmarked revenues, as well as the regional Rural Development Programmes; irrigators through the intertemporal allocation of water (although subject to limitations).

3.1.3.4. Tympaki River Basin (Greece)

The main actors are the Region of Crete and the Municipalities for the study, design and implementation natural water retention works. Regarding groundwater artificial recharge, the WDC is also involved in the issuing of the water use license and DEYAR (in case they provide treated wastewater for this purpose). The Special Secretariat for Water has also been involved in drafting the existing specifications and requirements for groundwater artificial recharge.

3.1.3.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

In Peru there two entities which are key in the implementation of NbS for water storage, The National Water Authority (ANA), and The Ministry of Environment (MINAM). ANA is a public entity attached to the Ministry of Agriculture and Irrigation, that exercises the technical and normative authority of the National System of Water Resources Management. It is responsible for managing, conserving, protecting, and using the water resources of the different basins in a sustainable way, while promoting public interest and efficient allocation. It also grants water use rights and authorizations, authorizes works in natural water sources, and supports participatory processes for dialogue and consensus building among water stakeholders, which in the case of the region of our project is responsible of many initiatives for NbS implementation. MINAM formulates and implements policies, plans, programs, and projects for the sustainable management of natural resources and the environment, as well as for the provision of basic sanitation services. It also develops and applies environmental regulations, environmental protection, and conservation, implements climate change adaptation and mitigation measures, manages protected areas and biodiversity conservation, and oversees the quality and efficiency of water supply and sanitation services.

In the case of Bolivia, key role players for NbS out from the national policy, are environmental NGOs. UNESCO, through its World Water Assessment Programme, which produces the United Nations World Water Development Report that promotes NBS for water and provides guidance and recommendations for policy makers and practitioners. Agua Sustentable is a Bolivian non-governmental organization that works on water governance, climate change adaptation, and NBS for water in the altiplano. It implements projects such as restoring wetlands, promoting agroecology, and strengthening local capacities.

3.1.3.6. Mahanadi River Basin (India)

The state watershed development agency of the respective states. In the case of Odisha, it is Directorate of Soil Conservation and Watershed Development. In the case of Chhattisgarh, it is Chhattisgarh State Watershed Management Agency (CGSWMA).

3.1.3.7. Murray-Darling Basin (Australia)

The Murray–Darling Basin Authority (MDBA) sets priorities for NbS environmental water use and target sites, the Commonwealth Environmental Water Office (CEWO) assess those priorities and devises a strategy to meet them for the year, and the MDBA River Operations team sets aside and delivers water from storages as directed by the CEWH—who technically owns and allocates the water from federal accounts like any other consumptive user. Monitoring and evaluation of success is undertaken by multiple administrative bodies (e.g. MDBA-TLM, CEWO, state agencies, local authorities and IIOs, environmental groups etc.)

3.1.3.8. Orontes River Basin (Lebanon)

The Ministry of Energy and Water (MoEW), Ministry of Environment (MoE), the Ministry of Agriculture (MOA), and Green Plan (GP).

3.1.4. What is the status of implementation of NbS?

Describe the prevalence of NbS for water storage in the area.

3.1.4.1. Júcar River Basin (Spain)

Little to none in the Júcar RB.

3.1.4.2. Nitra River Basin (Slovakia)

The Ministry of Environment as the coordinator is responsible for implementing the Water Policy 2030 and will be monitoring progress of the policy implementation, which will be monitored once a year. The progress will be evaluated twice, in 2027 and at the end of the policy duration in 2030.

In line with the EÚ legislation, member states report on adaptation progress to the Commision, latest report deadline being March 2023. The Ministry of Environment has presented a report on adaptation progress.

3.1.4.3. Reno River Basin (Italy)

Limited. Relevant pioneering applications in neighbouring areas do exist (FIA), as well as in the Reno Basin in the Secchia (MARSOL Project) and Val Marecchia (TRUST Project) (Nomisma, 2019; Rossetto and Bonari, 2014).

3.1.4.4. Tympaki River Basin (Greece)

In the Crete River Basin District (EL13), several artificial recharge projects have been carried out, with the most important ones at the area of the western Messara plain (next to Tympaki basin) and at the GWB PORODES MYRTOU (EL1300124). There are several small-scale projects scattered around the island that support the local aquifers.

In the Tympaki basin, natural water retention/detention ponds have been constructed along the Geropotamos river bed (Koutsoulidis branch) downstream of the Faneromeni Reservoir.

3.1.4.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

In Peru there are a few examples of NbS implementaions, Huamantanga is one of then near the area of the systema for the project. It is a village in the Andes that uses an ancient technique called amunas to divert wet-season water into underground channels and store it in natural reservoirs. This extends water availability into the dry season and increases crop yields. The project is supported by The Nature Conservancy and other partners. According to some of the interviews with local stakeholders from the pacific region, the national government in Peru has 5% of the infrastructure implemented with NbS projects, specifically in Caplina, Locumba and Sama basins the projection could rise to 15% nowadays. In the case of Bolivia there are some pilots made by the NGOs which must be quantify in next steps of the project but considering the limitations of government support long term operation is very uncertain.

3.1.4.6. Mahanadi River Basin (India)

The nature-based solutions that are tried in India in the water sector are mainly watershed development activities. They include afforestation, treatment measures for soil & water conservation and water harvesting. Such activities are implemented on a large scale by the state watershed management agencies of the two states viz., Odisha and Chhattisgarh in the Mahanadi river basin as well. The physical conditions (hydrology, climate and topography) are ideal for implementing watershed management in Mahanadi basin area of both the states. However, these activities are not implemented with due consideration of the various hydrological processes (infiltration, percolation and evapotranspiration) that alter water availability with respect to space and time. Very little scientific inputs in the form of data on rainfall, runoff, infiltration, geology and geohydrology go into planning such activities. There is no scientific evidence of improved storage of soil moisture or surface water or groundwater in the catchments (where they were tried) which actually improves the effective water availability for various uses.

3.1.4.7. Murray-Darling Basin (Australia)

In the MDB it is fully implemented and has been operational for around 10 years. While some issues remain (i.e. sustainable diversion limit [SDL] adjustment mechanisms and their use to offset economic losses), and the recovery of sufficient water to meet annual NbS requirements has stalled, the CEWH owns around 20% of annual average water supplies and uses that to deliver NbS goals across the MDB as stated above. Mostly this has resulted in god outcomes and lessons for managers, who have adopted changes through trial and error, and developed pathways for achieving better outcomes from limited water across multiple sites.

3.1.4.8. Orontes River Basin (Lebanon)

Although an action plan is available, it has not been implemented yet.

3.1.5. Identify barriers and enablers for the implementation of NbS for water storage

What are good practices of successful implemented NbS, and what factors contributed to their success? What are the potential barriers or challenges to integrate NbS in water quantity management and how can they be addressed?

3.1.5.1. Júcar River Basin (Spain)

Obtaining funding and coordination between administrations is complex and can slow down the implementation of NBS projects.

Short-term budgets and lack of long-term vision from the policy sector. Many of the benefits (co-benefits) of NBS are not immediate. The short-sighted vision of the government can lead to a lack of investment in this type of project. Lack of coordination between administrations at the different scales and the lack of coordination for financing or maintaining NBS may hinder their implementation.

3.1.5.2. Nitra River Basin (Slovakia)

In the conditions of the Nitra river basin, it will mainly be about the proper implementation of the Water Policy Concept, which determines specific goals and measures until 2030, including the institutions responsible for their implementation. The concept envisages the use of NbS "wherever possible". The key barriers are financing and awareness of the relevant stakeholders.

3.1.5.3. Reno River Basin (Italy)

An advantage of NbS for water storage is that they store water while producing ancillary benefits, environmental (aquifer recharge) and economic (biomass for wood and energy production in the case of FIA, for example). The private benefit of this approach is nonetheless constrained by the limited security on the availability of water during an hypothetical drought year, where water resources stored mostly by farmers can be allocated to other uses (urban, environmental) without compensation. In this sense, the pecuniary compensation through PES offered by regional authorities (e.g. PSR of the Veneto Region) and municipalities can help underpin the development of such approaches.

3.1.5.4. Tympaki River Basin (Greece)

No specific barriers.

3.1.5.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

In the case of Peru, we can list some barriers like the lack of awareness and understanding of NbS and their benefits; lack of accessible funds and economic appraisal methods for NbS; limited availability of knowledge and data on NbS performance and impacts; lack specific regulation to implement NbS in the country. As enablers we can mention the recognition of NBS as a key alternative to ensure water security in water scarcity regions; integration of NBS into national and local policies and plans; development of innovative financing mechanisms and incentives for NBS; promotion of participatory and collaborative approaches for NBS design and implementation.

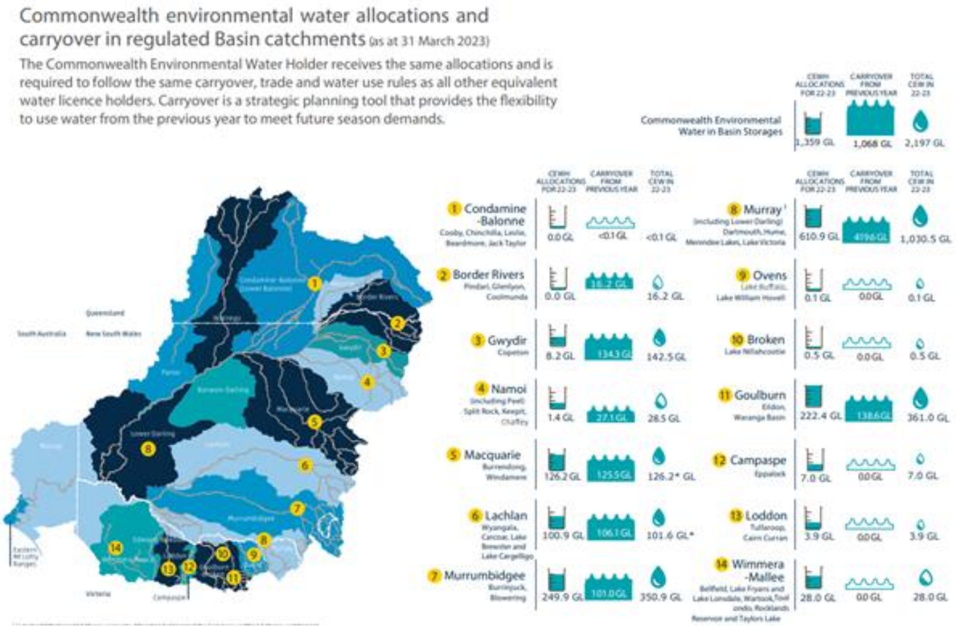
In the case of Bolivia, there are several limitations to developing nature-based solutions that are supported by the government, not if the approach to actions is justified under formal definitions. At the local level, there are many needs that can help adopt NbS technologies, such as artificial wetlands for household water treatment and storage processes in rural communities that have sufficient spaces, however the pilots applied in the country would remain private initiatives.

3.1.5.6. Mahanadi River Basin (India)

There need to be better application of the available scientific knowledge about how various land uses alter catchment hydrology, particularly the differential impacts of afforestation, grass plantation, soil conservation works such as terracing, bund, contour trenches etc. on runoff, soil erosion, runoff intensity and groundwater recharge need to be better understood. The general notion among watershed management professionals that afforestation would improve infiltration and augment groundwater recharge has little scientific basis.

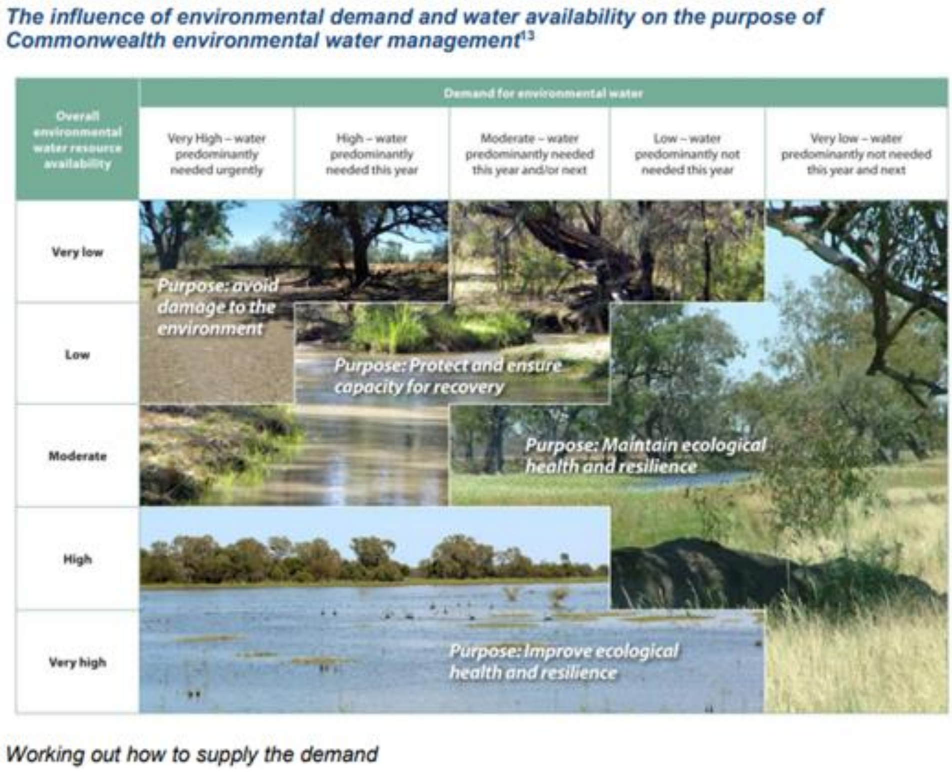
3.1.5.7. Murray-Darling Basin (Australia)

Water storage in the MDB remains the single most important source of supply, as the original rights were held by irrigators and delivered via irrigation schemes. Those rights have not changed in terms of conditions, use constraints or nature of reliability—they have simply changed ownership. Hence, they operate as any other right, used instead to irrigate the environment. While the delivery of substantial water at a time can result in some localized flooding and inundation, creating tension between farmers and federal water managers, this barrier is slowly being worked on to reduce future events. For an idea of how much water is in storage at any time, and the proportion of federal water (Total CEW as shown below on right) we have resources like this website below:



Source: (DCCEEW, 2023)

In addition, water management barriers such as drier conditions can be evaluated and assisted toward consistent water allocation and application decision-making via matrix charts such as the following:



Source: (DEE, 2018)

As shown, supply and demand factors for water can be considered together to help manage constraints or priorities as needed, given annual conditions.

3.1.5.8. Orontes River Basin (Lebanon)

Barriers are mainly related to the lack of enforcement and updates of laws, policies and regulations, availability of funds, and limited knowledge and experience in implementation and adaptation of nature based solutions. Guidelines and policies can be developed for nature based project implementation at the national level.

4. Non-conventional water sources

4.1. Status

Non-conventional resources include rainwater use, reuse of wastewater, and desalination (managed aquifer recharge or other NbS for water storage included in the previous section are excluded).

4.1.1. Which non-conventional water sources are available, and how are they currently utilized?

4.1.1.1. Júcar River Basin (Spain)

The little remaining potential to make use of surface resources, the intense overexploitation to which a large part of the underground resources are subject and the forecasted reduction in runoff due to the effect of climate change, make non-conventional resources strategic resources in the Júcar River Basin. The reuse of water was up to 100 Mm3 in 2019, around 1/3 of the total potential reuse. The main measures that are considered necessary to promote reuse in the Demarcation are:

- Regulatory changes that promote reuse. Application of the polluter pays principle, so that the urban user returns the resource to the environment with sufficient quality to be used for other purposes.
- Promote instruments that encourage the use of renewable energies and/or the coordination with the energy sector so that the increase of the resource is not an impediment.

The maximum desalination capacity in the Demarcation is 112.8 hm3 /year, which is concentrated in 7 production plants distributed along the coast. However, two of them are included in the system of the Mancomunidad de Canales del Taibilla (Alicante I and Alicante II) so their production is counted as an external water resource. The maximum capacity of the other 5 facilities (Jávea, Moncofa, Mutxamel, Orpesa and Sagunt) totals 64.8 hm3/year.

4.1.1.2. Nitra River Basin (Slovakia)

In the upper reaches of the Nitra RB in the location of our living lab, the coal mining activity is phasing out and is scheduled to finish by the end of 2023. Previously, a drainage network made it possible to mine the coal and the groundwater was controlled through this drainage. This drainage provided a source of water at about 80L .s-1. However, the state did not support maintenance of the drainage system and the mines started to dismantle it. Hence, a source of water that could be used for geothermal energy or as a water supply for the wetlands that formed as a result of the mining activities and hold rich biodiversity and large carbon stocks was essentially lost. It is currently unknown whether this source could be used in the future again. It is also not known how will the unregulated groundwater drainage system affect the groundwater level and the wetlands. There are still wells in the area that use this source of groundwater for example tomato greenhouses and catfish farming (supposed to be the largest fish farm in Europe).

4.1.1.3. Reno River Basin (Italy)

There is no meaningful supply of desalination, treated wastewater or other non-conventional water resources, neither in the Reno Basin nor in Italy—aside from managed aquifer recharge. The only desalination plants are located in islands in Sicily, Tuscany and Lazio. In the Po River Basin where the Reno Basin is located, during the 2022 drought, a desalination plant from Spain with the capacity to desalinate 100 000 liters per hour was temporarily installed in Taglio di Po (Veneto Region) a rental cost of 150 000 EUR for two months. The plant was meant to supply drinking water to 5 000 people in Taglio di Po and Ariano nel Polesine, whose typical water source was non-drinkable due to the unparalleled saline intrusion into the Po Delta (30 km upstream).

The new Water Protection Plan of the Emilia-Romagna Region will also deepen this project hypothesis, as part of the diversification strategies and increase of the available water resource, although, at the moment, this is not a hypothesized solution for the Reno basin.

In Emilia-Romagna, the reuse of waste water is already promoted by the current planning (PTA 2005) as well as by the new Water Protection Plan. In addition to the regional experience of the pilot plant for the recovery and reuse of waste water in agriculture at the Mancasale treatment plant (Reggio Emilia), other experimental activities are being developed in the Reno basin. An example is the Program Agreement between the Region, Atersir, Arpae, Hera and the Reno Basin LRB (Consorzio della Bonifica Renana) for the launch of an experiment aimed at defining the ideal conditions to ensure, through the modulated management of the recovered wastewater of the IDAR purification plant, the maintenance of a base flow rate in all hydrological conditions in the Navile canal and in the Savena Abbandonato; the use of recovered wastewater from the IDAR purification plant is also for irrigation as well as environmental purposes.

The Reno Basin LRB, thanks to a 2,000 km network of canals and 26 drainage systems, deals with the collection and removal of rainwater in the Bologna plain, protecting the territory from hydraulic risk. In addition, through 1,455 canals and pipelines, it distributes an average of 70 million cubic meters of surface water for irrigation and production uses annually. These functions are carried out with specific attention to the environmental sustainability of the overall water balance.

The experimental agreement for the recovery of wastewater leaving IDAR (Wastewater Purification Plant), allows the Consortium to convey, through its own lifting plant and pressure pipe pipeline, a variable quantity of water from the Bologna purifier to the hydraulic node of the Savena Abbandonato. From there, this water potential is used for the maintenance of a suitable base flow in the Savena Abbandonato, and for the supply of the Dozza irrigation system and the network of canals and irrigation pipes served by this watercourse, as well as the other water uses granted. This also relieves the pressure on the Reno river and on the Navile canal.

4.1.1.4. Tympaki River Basin (Greece)

Treated wastewater is available for reuse in irrigation. DEYA Faistou has secured financing for the tertiary treatment upgrade of the Tympaki wastewater treatment plant in order to use the treated effluent for irrigation purposes (funding source Ministry of Internal Affairs, Program “Antonis Tritsis”). According to the Director of the Municipal enterprise DEYA Faistou, farmers will be positive to use the treated water because of their increased water needs.

Furthermore, harvested rainwater is practiced. It is permitted to build tanks in all areas of Crete that will use exclusively and only the drainage waters from the roofs of installed greenhouses or buildings and only for irrigation purposes of the same greenhouse that they were collected from or to serve the needs of the buildings they were collected from (i.e. in-situ use). The following conditions apply: the storage volume of each tank will be up to 500 m3 per three acres of greenhouse. Any tank with a storage capacity of more than 500 m3 has to be licensed.

4.1.1.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

From the system there are two regions which may be very positive and interested about non-conventional water sources, the pacific region, and the Maure – Mauri region. Desalination can provide freshwater for drinking, irrigation, and industrial uses in water-scarce regions. Desalination is used in some coastal areas of Peru to supply water for domestic and industrial purposes. However, there are no regulations or standards for desalination in Peru, and that there are potential impacts on marine ecosystems due to brine discharge.

Another non-conventional water source is rainwater harvesting is practiced in some rural areas of the TDPS system for domestic use and livestock watering. However, there are limitations related to the design, maintenance and management of rainwater harvesting systems, as well as the lack of policies and incentives to promote them [Rodriguez, V., et al, 2022].

Another source is the wetland of high altitude “Bofedales” are peat-forming wetlands that are found in the high-altitude regions of the Andes. Bofedales provide important ecosystem services and water resources for the local communities and wildlife, as they store and regulate water, support biodiversity and carbon sequestration, and offer grazing lands for livestock. Bofedales can be considered as a non-conventional water source, as they are not traditionally used for irrigation or domestic purposes, but rather for maintaining the hydrological balance and the cultural landscape of the Andean highlands. However, bofedales are also vulnerable to climate change, water extraction, land use change, and degradation, which threaten their functionality and sustainability. Bofedales are essential for the livelihood of the local population in the region of Maure - Mauri, who depend on them for water and food security. Bofedales absorb carbon dioxide and store water in their roots like sponges, releasing it during the dry season. Bofedales are threatened by the reduction of water flows from the rivers that feed them, this is the case with the transboundary river [Caquena, Uchusuma], as well as by the lack of maintenance and management practices. There is a pilot project that aims to revitalize bofedales by recovering and revaluing ancestral knowledge and applying current technologies in Charaña municipality in Maure – Mauri region in Bolivia24.

4.1.1.6. Mahanadi River Basin (India)

There is no use of non-conventional water sources such as desalination in the basin. There is also not much scope for it except in the coastal city of Cuttack in Odisha. Cuttack is relatively water-rich falling in the high rainfall region. There is also no evidence of reuse of treated wastewater in the basin.

4.1.1.7. Murray-Darling Basin (Australia)

Rainwater tanks are used to support rural MDB township drinking water needs, but with less application than previous decades as the requirement for water goes up, but rainfall declines. Other non-conventional sources include desalination treatment facilities, mainly built toward the end of the Millennium Drought (2000-2010) as water supplies were reduced to lowest levels on record. These facilities were mainly placed in large cities close to the coast (e.g. Sydney, Melbourne, Adelaide) to supplement water extracted from the Basin to support urban demand, and when completed many did not achieve full status as wetter conditions had returned. Note these water supplies are not used for agriculture within the Basin as the cost of supplying water over the mountain ranges that separate the Basin from the coast is substantial, and the volumes produced too low to meet any serious substitute requirement (e.g. 100GL annually on a 1,033GL demand profile in SA during 2020-21).

4.1.1.8. Orontes River Basin (Lebanon)

The Green Plan, a general directorate of Agriculture under the Ministry of Agriculture, supports investments in land reclamation and agriculture development such as rain harvesting. However, the Green Plan suffers from a sharp reduction in its budget, insufficient staff and updated legal framework. The National Water Sector Strategy, Lebanon's initial water policy strategy adopted in 2010, did not establish specific targets for the development of non-conventional water resources. However, the strategic environmental and social assessment advised the utilization of non-conventional water sources by promoting alternative technologies like rainwater harvesting. It also recommended incorporating rainwater harvesting requirements into building regulations for new facilities. It is important to note that currently, Lebanon lacks standards or regulations pertaining to rainwater harvesting and the utilization of rainwater.

4.1.2. How is the use of non-conventional water sources promoted (or controlled) (e.g. awareness, subsidies)?

4.1.2.1. Júcar River Basin (Spain)

The National Plan for Purification, Sanitation, Efficiency, Saving and Reuse (Plan DSEAR) is a governance instrument that aims to incorporate, in the hydrological plans of the third cycle (2022-2027), improved procedures and work methodologies aligned and focused on meeting the objectives of hydrological planning, mainly in the areas of purification, sanitation and reuse of regenerated wastewater. The Plan reviews the strategies and actions that define water policy in these matters, seeking to align them with the community policies related to the European Green Deal, and the national ones of ecological transition and demographic challenge.

In its final phase of preparation, the General Directorate of Water submitted between October 23 and December 31, 2020 the draft Plan DSEAR and its strategic environmental study to a participatory process, which included making it available to the public to gather their opinions; consultation with the affected administrations and the interested public, determined by the environmental body of the strategic evaluation procedure; and two additional participatory activities, consisting of a web survey and a webinar (web conference).

As a result, a report on the participatory process was prepared, analyzing and responding to the proposals, observations and suggestions presented, which were incorporated as far as possible in the proposal of the Plan DSEAR and its environmental study. The version of the Plan adjusted after the public consultation was presented on April 30, 2021 at the National Water Council, which issued its mandatory favorable report.

In parallel, and in accordance with the provisions of Law 21/2013, of December 9, on environmental assessment, the Plan DSEAR has been subject to an ordinary strategic environmental assessment. As a result of this, the strategic environmental declaration was published in the BOE of June 18, 2021. This document establishes the environmental determinations that allow improving the integration in the Plan of these environmental aspects.

4.1.2.2. Nitra River Basin (Slovakia)

The use of non-conventional water sources such as the contaminated water from the mine is promoted under the revitalization projects of the former mines in the region implemented in the Acton plans for the Upper Nitra region. Other actions include workshops, projects but more in a way of passive information.

4.1.2.3. Reno River Basin (Italy)

The Italian National Plan for Recovery and Resilience (Piano Nazionale di Ripresa e Resilienza, PNRR) identifies four items of investments with the aim of "guaranteeing the security of supply and the sustainability of water resources", which have been allocated 4.38 billion EUR, of which about 50% are dedicated to “primary water infrastructure for water supply security”. Yet, the Legge Salvamare (Gazzetta Ufficiale 10 June 2022, n. 60) of “Provisions for the recovery of waste at sea and in inland waters and for the promotion of the circular economy” has been identified as a barrier due to the regulatory process it imposes on the approval of desalination plants and the higher costs it will impose on this technology (https://www.althesys.com/wp-content/uploads/2022/06/CS-29-giu-22-Althesys-Acciona-dissalazione.pdf).

Desalination concerning the River Reno basin is not one of the key points, given the fact that only the river mouth is interested by this issue.

Water reuse is already promoted by the PTA (2005), Work and Climate Agreement and DEFR (Economic and Financial Regional Document) and it is one of the goals of the Agenda 2030. Moreover water reuse will also be promoted by the new PTA (Plan of Environmental Protection) in which desalination will be mentioned as well.

4.1.2.4. Tympaki River Basin (Greece)

The use of treated wastewater for irrigation is promoted with the RBMP, as well as through campaigns of the Region of Crete. Financial incentives are also provided to farmers for using treated wastewater in irrigation, i.e. free of charge for the first few years. Regarding rainwater harvesting, the storage tanks usually are funded by the state or the region for new farmers, occasionally for old farmers too.

4.1.2.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

One of the priority problems identified for the regional system TDPS is the limited availability of water. Non-conventional water sources can be part of the solution to this problem, by increasing water storage and regulation capacities, diversifying water sources, and reducing water losses. A diagnostic related to TDPS system mentions some institutions that are involved or could help to implement non-conventional water sources projects, such as: 1) The Binational Autonomous Authority of the Lake Titicaca-Desaguadero River-Lake Poopó-Coipasa Salt Flat Hydrological System (ALT), they have developed several studies and projects in the region, such as bofedales revitalization, wastewater treatment plants, rainwater harvesting systems, and desalination feasibility studies, 2) The Ministries of Foreign Affairs, Environment, and Water of Bolivia and Peru: These are the national authorities responsible for defining and implementing policies and strategies for water resources management and environmental protection in their respective countries, they have supported and promoted several initiatives related to NCWS in the region, such as wastewater reuse regulations, bofedales conservation programs, rainwater harvesting pilot projects, and climate change adaptation plans, 3) The United Nations Development Programme (UNDP) and the Global Environment Facility (GEF), They have supported and funded several projects related to non-conventional water sources in the TDPS system, such as the Integrated Water Resources Management (IWRM) project, which aims to update the binational master plan for the TDPS system25.

4.1.2.6. Mahanadi River Basin (India)

There are no special mechanisms to promote non-conventional water sources existing in the basin or in the party states.

4.1.2.7. Murray-Darling Basin (Australia)

This is not really an issue for the MDB or Australia generally. Subsidies for water and its use are not really used to any great effect in this context—excepting some incentives to recover water periodically for the federal government's environmental flow program and Commonwealth Environmental Water Holder (CHEW) accounts.

4.1.2.8. Orontes River Basin (Lebanon)

The NAS promotes sustainable use of natural resources to reduce environmental and natural resource degradation, and it promotes the adoption of modern irrigation techniques.

4.1.3. What are good practices of successfully implemented non-conventional water sources, and what factors contributed to their success?

4.1.3.1. Júcar River Basin (Spain)

The last

4.1.3.2. Nitra River Basin (Slovakia)

A more significant use of rainwater is hindered by insufficiently built reservoirs, but also by a lack of previous experience with their use on a larger scale. The focus is to use the groundwater from the former mine for the purposes of agriculture, farming (aquaculture) and for the purpose of recreation. There are, for example, greenhouses for growing tomatoes and fish farm that use the geothermal potential of the mining groundwater and there are plans to extend these agri and aquacultures. The mining water could also be potentially used for supplying the wetlands, which needs to be, however, further explored. Project DEEPWATER at the WRI, for instance, explored the possibilities of replenishing groundwater aquifers from the surface water. There are also other projects, usually run by NGOs for water retention measures in forests and within the landscape in general. However, the credibility of some of them may be questionable.

4.1.3.3. Reno River Basin (Italy)

PNRR allocates 4.4 billion EUR to primary infrastructure for water supply security.
An example of good practice is linked to the water purifier of Bologna (IDAR - Purification Plant of Waste Waters), described in question 4.1.1.3.

4.1.3.4. Tympaki River Basin (Greece)

Farmers have some reservations around using treated wastewater for irrigation. A good practice already implemented in Crete is the provision of economic incentives to the farmers: the use of treated wastewater for irrigation was provided free of charge for the first few years (this has been applied in to the Heraklion treated wastewater).

4.1.3.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

There are few examples of successful implementation of non-conventional water sources, mainly because of issues about social acceptance and long-term sustainable operation of these kinds of solutions. We focused on one example which may be very illustrative. The project of revitalization of bofedales in Charaña is a pilot project that aims to conserve and restore these ecosystems by recovering and revaluing ancestral knowledge and applying current technologies. The project is part of the Integrated Water Resources Management (IWRM) project for the TDPS system, which is a transboundary hydrological system shared by Bolivia and Peru. The project is supported by the Binational Autonomous Authority of the TDPS system (ALT), the United Nations Development Programme (UNDP), and the Global Environment Facility (GEF). Some of the lessons learned and points of successful implementation of the project are: 1) The involvement of local communities and authorities is crucial for the sustainability and ownership of the project. The project has engaged with the beneficiaries and technicians of the municipality of Charaña through participatory workshops, trainings, field visits, and validation processes. The project has also respected and incorporated the local culture, cosmovision, and values in the design and implementation of the project activities, 2) The integration of traditional and scientific knowledge is key for the effectiveness and innovation of the project. The project has recovered and revalued ancient practices of bofedales management, such as rotational grazing, selective weeding, fire control, and water distribution. The project has also applied current technologies, such as satellite imagery, hydrological modeling, soil analysis, and ecological restoration techniques, 3) The coordination and cooperation among different stakeholders and institutions is essential for the scalability and replicability of the project. The project has established synergies and partnerships with various actors at different levels, such as the ALT, the Ministries of Environment and Water of Bolivia and Peru, the UNDP, the GEF, Mayor de San Andres University, the National Institute of Agricultural Innovation in Bolivia, and other NGOs and research centers. The project has also contributed to update the binational master plan for the TDPS system with a focus on non-conventional water sources26.

4.1.3.6. Mahanadi River Basin (India)

No evidence of implementing any good practices with regard to adoption of non-conventional water sources encountered in the basin.

4.1.3.7. Murray-Darling Basin (Australia)

Not applicable.

4.1.3.8. Orontes River Basin (Lebanon)

Several successful initiatives have been implemented in Lebanon to demonstrate the effectiveness of non-conventional water sources, such as rainwater harvesting. One notable example is the rainwater harvesting pilot program implemented by ACTED in Akkar, which provided a decentralized solution to address the water needs of vulnerable families. Through the installation of rainwater harvesting systems, over 100 families benefited, reducing their expenditure on water significantly. Additionally, rainwater harvesting projects have been successfully applied in the agriculture sector, including collecting rainwater in agricultural greenhouses and constructing hill lakes. These initiatives have not only increased agricultural revenues and secured water availability but also served as good practices for sustainable water management. Rainfall in the Orontes in Lebanon may be torrential in summer on the eastern slopes, causing massive floods that destroys property at times.

4.1.4. What are the potential barriers or challenges to integrate the use of non-conventional water sources and how can they be addressed?

4.1.4.1. Júcar River Basin (Spain)

- No application of the polluter pays principle, so that the urban user returns the resource to the environment with sufficient quality to be used for other purposes.
- Not enough awareness of the instruments that encourage the use of renewable energies and/or the coordination with the energy sector.
- Not enough awareness about the safety of reusing water by farmers and local authorities.

4.1.4.2. Nitra River Basin (Slovakia)

A potential obstacle to the use of mine waters or waters originally from mining activities is their limited use for other purposes due to, e.g., contamination, legislation, conflicts in competences. A more significant use of rainwater is hindered by insufficiently built reservoirs, but also by a lack of previous experience with their use on a larger scale. Rainwater is, according to the current legislation, still considered waste water and the traditional way of dealing with rainwater has been to transport it to the water courses as quickly as possible. This increases the risk of floods in case of heavy or prolonged precipitation events.

4.1.4.3. Reno River Basin (Italy)

Regulatory provisions, high costs (2-3 EUR/m3 in Italy) relative to those of conventional resources (which range from less than 1 Eurocent to 0).

More specifically, several challenges, resulting from a way too complex system, concern the reuse practices. These barriers concern administrative and legislative aspects (some obligations are impossible to overcome); regulation and responsibility problems; actual costs, their distribution (normally the beneficiary sector should be in charged) and their repartition, considering that also in case of financing from ARERA (Authority of regulation for energy, water networks and environment), it is impossible to overcome certain legislative obligations. Other barriers concern certification and technology aspects. All of this is the result of a lack of research and development in this field.

4.1.4.4. Tympaki River Basin (Greece)

Farmers are reluctant to use treated wastewater for irrigation as they feel it is of a lower quality and will thus impact their crop yields and market value of their products. This is mostly a physiological and mentality issue, and they prefer to use groundwater even if it is more expensive. They revert to using treated wastewater only in cases of water scarcity, where freshwater is not available due to limited availability. This can be addressed through education, and documented evidence that their products market value will not be reduced as a function of having used treated wastewater for their irrigation.

4.1.4.5. Caplina-Mauri-Desaguadero System (Peru, Bolivia, Chile)

Barriers and challenges can be addressed from a technical, institutional, and social point of view.

Technical: non-conventional water sources may require specialized processes or technologies that are not widely available or affordable in the region and the systems of basin for the project. For example, desalination may be costly and energy-intensive, rainwater harvesting may depend on rainfall variability and storage capacity, and atmospheric water may have low yields or quality issues. In an interview with the entity in charge of the water resource plan from the pacific region of the system [Huanacuni C., Cambillo C. 2023], we know about desalinations plants implemented by the regional government of Tacna in Peru however, there are some challenges in the maintenance and cost efficiency of the current operation which is consider a pilot project, not at the scale to be considered a formal water sources in comparison with the pumping systems, dams and any other conventional infrastructure implemented by the water users.

Institutional: non-conventional water sources may involve different stakeholders and institutions that need to coordinate and cooperate across different scales and sectors. For example, treated wastewater may require collaboration between municipal authorities, water utilities, farmers, and consumers; rainwater harvesting may involve community participation and management; and atmospheric water may need regulation and monitoring, which in the case of the system is not feasible due to the regional water scarcity situation. In a project related to the Regional Master Plan for the complete systems

[TDPS], PNUD funded by GEF transboundary project invest in pilots related to restoration of high-altitude wetland [bofedales] to be used as a water and vegetation sources for small community activities related to camelids27. Examples like this can be searched in the other parts of the system for the project.

Social challenges: non-conventional water sources may face social acceptance or perception barriers that affect their adoption and use. For example, treated wastewater may be rejected by consumers due to health or cultural concerns. In the case of the system, small communities near the transboundary regional [Maure-Mauri] are very reluctant to any change in the conditions about water sources considering conventional interventions such as intakes and dams, this could create a good opportunity to suggest non-conventional options.

4.1.4.6. Mahanadi River Basin (India)

There is no wastewater reuse policy existing in any of the two states. There are no special economic incentives for encouraging reuse of treated wastewater in any of the sectors.

4.1.4.7. Murray-Darling Basin (Australia)

Main barrier is the cost to implement non-conventional sources such as desalinated water, and then treat and deliver it, in significant volumes, to users often hundreds of miles away and over significant mountain ranges. Cheaper to source water at local points and surface river systems or groundwater sites, and then store or deliver it as needed.

4.1.4.8. Orontes River Basin (Lebanon)

Rainwater harvesting faces several challenges, for instance Lebanon lacks standards or regulations pertaining to rainwater harvesting and the utilization of rainwater (no clear regulations). Other challenges include technical considerations requiring expertise, the cost and affordability of installation, space and infrastructure constraints, and the impact of climate variability. Collaborations between government, NGOs and international organizations, along with the development of national guidelines, and financial support from funding agencies can highly contribute to the success of non-conventional water sources.

Regarding wastewater treatment, it poses significant challenges, primarily due to high operational costs, which needs to be covered from unaffordable household subscriptions (estimated at $138 USD per year per a 4.6 people household. Alongside financial constraints, there are organizational and management hurdles that need to be addressed. These include the rehabilitation or replacement of old networks and infrastructure, incomplete data on system characteristics, inadequate service coverage for the population, frequent service interruptions and water shortages, high levels of non-revenue water, low collection rates, a shortage of skilled personnel, and dependence on international aid to cover financial shortfalls resulting from budget deficits and insufficient income.

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Agriculture	Forest	Hydro Morphology	Urban
Meadows and pastures and also the last	Forest riparian buffers	Basins and ponds	Green Roofs
Buffer strips and hedges	Maintenance of forest cover in headwater areas	Wetland restoration and management	Rainwater Harvesting
Crop rotation	Afforestation of reservoir catchments	Floodplain restoration and management	Permeable surfaces
Strip cropping along contours	Targeted planting for 'catching' precipitation	Re-meandering	Swales
Intercropping	Land use conversion	Stream bed re-naturalization	Channels and rills
No till agriculture	Continuous cover forestry	Restoration and reconnection of seasonal streams	Filter Strips
Low till agriculture	'Water sensitive' driving	Reconnection of oxbow lakes and similar features	Soakaways
Green cover	Appropriate design of roads and stream crossings	Riverbed material renaturalization	Infiltration Trenches
Early sowing	Sediment capture ponds	Removal of dams and other longitudinal barriers	Rain Gardens
Traditional terracing	Coarse woody debris	Natural bank stabilisation	Detention Basins
Controlled traffic farming	Urban forest parks	Elimination of riverbank protection	Retention Ponds
Reduced stocking density	Trees in Urban areas	Lake restoration	Infiltration basins
Mulching	Peak flow control structures	Restoration of natural infiltration to groundwater	
	Overland flow areas in peatland forests	Re-naturalisation of polder areas	