Deliverable 1.3: TALANOA DIALOGUE REPORT II

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☐ CO = Confidential, restricted under conditions set out in Model Grant Agreement

☐ CI = Classified, information as referred to in Commission Decision 2001/844/EC.

Acronym List

Acronym/Abbreviation	Definition
AUB	American University of Beirut
CMCC	Centro Euro-Mediterraneo sui Cambiamenti Climatici
CRDA	Commissariat Régional de Développement Agricole
GPAI	Green Power for Agriculture and Irrigation
INAT	Institut National Agronomique de Tunisie
INRAE	National Research Institute for Agriculture, Food and the Environment
USAL	Universidad de Salamanca
WP	Work Package
GECOS	GECOsistema

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1. Executive summary

The "Talanoa Dialogue Report" provides an overview of the progress in Talanoa Water Dialogue, a research methodology aimed at fostering inclusive and participatory discussions on Transformational Adaptation to Water Scarcity Under Climate Change. The report highlights the concept of Talanoa and its application as a research approach.

The report further delves into the specific application of Talanoa Dialogue to the 6 pilot "Water Laboratories" in Spain, France, Italy, Lebanon, Tunisia, and Egypt, each facing a peculiar challenge in the general framework of water scarcity under climate change conditions. The Labs entail active participation of relevant stakeholders involved in the water sector. For each laboratory, it outlines the current situation, desired goals, and strategies to achieve them. Key messages from periodic workshops, targeting specific activities of the project, are also summarized for each laboratory.

This process is actively supported by the Champions Team, made by representatives of the project Work Packages and laboratories, periodically meeting with the scope of facilitating the dialogue, reviewing the progress also by means of synthetic indicators, encouraging incorporation of relevant innovations and feedback from the activities with stakeholders.

The report concludes by stocktaking of the discussions held during the various moments of interaction with stakeholders in the labs (particularly the periodic workshops) and provides a forward-looking perspective. It emphasizes the importance of continued collaboration and identifies areas for further exploration and action.

Throughout the report, possible concerns and limitations related to the Talanoa Dialogue and its practical application in the Lab activities are acknowledged, ensuring a critical and balanced view of its effectiveness for supporting Lab Coordinators in the preparation of the for the next round of planned activities.

Overall, the "TALANOA Dialogue Report" serves as a comprehensive resource that captures the essence of the Talanoa Dialogue and its application in the pilot labs. It offers insights into the current state, future aspirations, and strategic pathways towards achieving desired outcomes and effectively engaging stakeholders in the process.

1. Introduction: Talanoa Dialogue

1.1. Talanoa: The Concept

'Talanoa' is a Tongan word which, however, indicates a concept considered to be Pan-Pacific. Talanoa research builds upon the foundation of Talanoa dialogue, which is a long-standing Pasifika cultural practice. Prescott (2008) and Faʻavae et al. (2016, p. 140) noted that as "an oratory tradition, Talanoa is a concept recognized in Samoa, Fiji, Tonga, Cook Islands, Niue, Hawaiʻi and the Solomon Islands." The concept holds a "diversity of meanings" (Tagicakiverata & Nilan, 2018, p. 3) across these different Pasifika contexts. This diversity of meanings reflects cross-cultural differences in understanding Talanoa as an everyday cultural practice or way of being. However, across these various contexts, Fairbairn-Dunlop (2014) stated that "Talanoa is a traditional form of knowledge sharing that is often firmly rooted in the community and takes place orally and in person".

Talanoa can be referred to as a conversation, a talk, an exchange of ideas or thoughts, whether in a formal or informal setting. It is predominantly carried out through face-to-face interactions. "Tala" means to inform, tell, relate and command, as well as to ask or apply. "Noa" denotes something of any kind, ordinary, without specific significance, purely imaginary or void. Churchward (1959), in the Tongan dictionary he compiled for the Government, described Talanoa as to talk (in an informal way), to tell stories or relate experience (p. 447). Churchward (1959) mentioned that "Talanoa also means to command, tell, relate, inform and announce, and means common, old, of no value, without thought, without exertion, as well as dumb (unable to speak)." He also concluded that "Talanoa, then, literally means talking about nothing in particular, and interacting without a rigid framework."

Along with qualitative research, grounded theory, naturalistic inquiry and ethnography, Talanoa belongs to the phenomenological research family. Phenomenological research approaches focus on understanding the meaning that events have for participants (Patton, 1991). As Bishop (1996) suggests, "Talanoa's philosophical base is collective, orientated towards defining and acknowledging Pacific aspirations while developing and implementing Pacific theoretical and methodological preferences for research." He also added "Talanoa removes the distance between researcher and participant and provides research participants with a human face they can relate to." This method of research builds on relationships, the foundation on which most Pacific activities are built (Morrison et al., 2002). Whilst it is similar in approach to narrative research, Talanoa is different in the sense that participants in a Talanoa group will provide a challenge or legitimation to one another's stories and shared information. Because Talanoa is flexible, it provides opportunities to probe, challenge, clarify and re-align. It should thus create and disseminate robust, valid and up-to-the-minute information.

The main features of the Talanoa Dialogue are as follows: I– The dialogue should be constructive, facilitative and solutions oriented. II– The dialogue should not lead to discussions of a confrontational nature in which individual Parties or groups of Parties are singled out. III– The dialogue will be conducted in the spirit of the Pacific tradition of Talanoa, namely: 1) inclusive, participatory and transparent dialogue; 2) storytelling, to build empathy and trust; 3) building common understanding to advance knowledge; 4) improved decision making for the collective good through platforms for dialogue (Stakeholder Platform); and 5) informing better decision-making by focusing on the benefits of collective action.

1.2. Talanoa: A Research Methodology

The Talanoa Dialogue is operationalized in TALANOA-WATER through an iterative co-generation process involving five major steps: co-design, co-development, co-evaluation, co-identification and co-implementation.

The Talanoa Dialogue fosters an open and inclusive environment, devoid of blame, where stakeholders and scientists share stories and exchange points of view, so as to affect decision-making through consensus-building. The operationalization of the Talanoa Dialogue concept to affect decision making is done through an iterative stock-taking process involving steps, namely: 1) stakeholders and scientists **co-design** credible climate and socioeconomic scenarios, and sustainable Basin Determined Contributions (BDCs); 2) **co-design** of relevant transformational adaptation strategies, including financial mechanisms and partnerships to secure cost recovery and sustainable investment; 3) **co-development** of modeling efforts (including the use of stakeholders' models in the modeling framework, e.g. river basin authorities' own hydrologic models); 4) **co-evaluation** of adaptation strategies, combining mechanistic modeling outputs with heuristics and inductive reasoning (e.g. leveraging on stakeholders' experience to speculate upon the consequences of a given transformational adaptation strategy) so to identify strengths and vulnerabilities to selected strategies; 5) **co-identification** of the robust strategy with the highest potential attending to the IWRM criteria of efficiency, equity and sustainability; and 6) science-policy collaboration in the deployment of selected strategies through **co-implementation**. Note that as a result of continuous interaction and deliberation among stakeholders and scientists, a likely outcome of the co-identification stage is to reset the analysis considering alternative/additional strategies, model settings and/or scenarios/BDCs. The result is an iterative 'stock-taking' co-generation process, where stakeholders and scientists learn from each other, collectively create knowledge and build consensus, until a decision is agreed upon and collectively implemented.

The operationalization of the Talanoa Dialogue concept into the stock-taking co-generation process was detailed in Deliverable 4.1 of this project (D4.1).

Operationalization of this Talanoa Dialogue is already advanced as water labs have organized their second major workshop in spring 2023, including serious gaming experiences and gathering significant feedback. This will be further discussed in the next chapter devoted to the Champions Teams work, particularly in the synthesis Table 1 that keeps track of the outputs per Lab and WP.

Work from the Champions Team propels Labs to improve their engagement ambition workshop after workshop by outlining areas where there is more room for advancement, while providing guidance on how to achieve such advancement.

1.3. The Champions Team

To ensure that the project Consortium considers and responds adequately to the recommendations and suggestions from the Stakeholder Platform and Talanoa Dialogue in the pilot water laboratories, a Champions Team has been set up by mid-June 2022 including one representative for each WP. The Champions Team defines Champions indicators, which are a key mechanism within TALANOA-WATER for the partners to prepare for and follow-up from the Talanoa Dialogue, encouraging knowledge sharing, peer-learning and the incorporation of relevant innovations and developments, avoiding weak/inconsistent or unbalanced engagement of stakeholders in co-generation.

The impact Champions team meets periodically, before and after each science-policy workshop, updating its members on the outcomes from the previous round of engagement activities, including but not limited to workshops, and formulating suggestions and indications to WP leaders and Lab coordinators. In this stage of the Talanoa Dialogue process the team activity focused on definition/discussion on appropriate impact and performance indicators to measure work and goals' achievement.

The implementation status of the proposed indicators is to be reported in all labs by the lab scientific coordinator (GPAI in the Egyptian lab, INRAE in the French lab, CMCC in the Italian lab, USAL in the Spanish lab, INAT in the Tunisian lab, AUB in the Lebanese lab). For this reason, workshop organizers and Lab coordinators are requested to keep track of the indicators during workshops and other stakeholder meetings, including in the workshop/meeting minutes, to provide feedback to the Champions Team for its periodical meetings.

Hereafter follows a selection of the most relevant indicators used to keep track of progress in stakeholders' engagement through Talanoa Dialogue, as agreed on during the Champions Team early meetings. An exhaustive list of all the used indicators in provided in Annex 1 together with updates table of indicators status in the Workshops held until the present Report is written:

Indicators with focus on balanced and inclusive involvement

- Share of women that are part of the water laboratories (attending, reporting, contributing) and WS.
- Number of different types of organization involved in the Laboratories.

Stakeholders' involvement indicators

- Numbers of cards/ideas/tools used to collect feedback in the workshops (e.g., questionnaires, boards, games) listed in the minutes.
- Number of specific feedbacks collected towards WPs in the workshops.

Indicators on WP response to Stakeholders

- Number of specific feedbacks addressed in WPs before next workshop.
- Number of stakeholder models incorporated into the modeling framework in WP3 Number of scenarios co-designed by Stakeholders modeled in WP3.
- Number of TAP (Transformational Adaptation policies) co-designed by stakeholders modeled in WP3.

In November 2022 the Champions team met for the second time to assess the first round of interaction with users (first science policy workshops) and monitor the status of stakeholder engagement. To this end, the Champions Team assessed performance in terms of the indicators above, as well as other qualitative assessments submitted by lab scientific coordinators. The following table summarizes the self-evaluation the lab leaders implemented and brought to the Champions Team; by means of the above selected most relevant indicators, the full and commented Table 14 is reported in Annex 1.

	ITA1	LEB1	FRA1	SPA1	TUN12	EGY1	ITA2	FRA2	SPA2	LEB2	TUN2	*EGY2*
Indicators	**29-07-22**	**13-07-22**	**16-06-22**	**29-30/09/-22**	**1-23/09/22**	**9/6/2022**	**29-03-23**	**9/3/2022**	**13-14/04/23**	**27-04-23**	**08-09/03/23**	***24/06/23***
Indicators on balanced and inclusive involvement												
% of women that are part of the water laboratories (attending, reporting, contributing) and WS	8/12 66%	8/12 27%	14/36 39%	6/30 20%	13/67 20%	16/76 21%	44/12 33%	15/44 44%	2/18 11%	6/13 46%	9/47 19%	*40/75 53%*
Number of different types of organization involved in the Laboratories	6	11	8	15	7	9	6	9	8	11	10	*15*
Indicators on stakeholders' involvement												
Number of cards/ideas/tools used to collect feedback in the workshops (e.g. questionnaires, boards, games) listed in the minutes		5	5	3	14	15	5	3	5	13	6	*8*
Number of specific feedbacks collected towards Work Packages in the workshops	6	9	7	10	6	3	6	5	5	6	7	*6 expected*
Indicators on WP response to Stakeholders												
Number of specific feedbacks addressed in WPs before next workshop	1	2	not yet	11	not yet	3	4	1	1	4	not yet	*not yet*
Number of stakeholder models incorporated into the modeling framework in WP3 (e.g., AQUATOOL)		1	0	1		2	1		1	2	1	*2 expected*
Number of TAP co-designed by stakeholders modeled in WP3 (and % over total TAPs simulated - ideally it should be 100%)				>10		3		4	>10	3	6	*3*

Table 1. outcomes of the Champions Team for the most relevant indicators, after both the first and second rounds of workshops (planned workshops and expected results in Italic), self-evaluation table developed by Lab leaders.

1.4. Main achievements

The above table shows, as expected, a diversified status among the labs and different areas for possible improvement, with all the labs already succeeding in involving a wide range of stakeholders and regularly meeting them to collect baseline data (*Where we are* in the Talanoa Dialogue framework, see chapter 2), as well as feedback towards defining sustainable Basin Determined Contributions (BDC) and transformational adaptation strategies (*Where do we want to go* and *How do we get there* in the Talanoa Dialogue framework).

To further assess stakeholder engagement the Champions team asked all the Lab leaders to prepare synthetic workshop minutes. Given the need to get comparable and homogenous feedback, a template was provided after the first round of workshops to standardize contents.

Furthermore a joint reflection on key outcomes and messages for possible improvements took place in the November meeting, leading towards targeted suggestions for specific areas of interaction with stakeholders (*Engage, Modeling, Laboratories and Exploit*), to be passed to corresponding WP and task leaders for the next round of interaction with Stakeholders.

By the time of this Report, the Champions team has held three meetings, the third of them taking place in May 2023, after the majority of the II round of workshops took place. This last interaction round led to a discussion in the team regarding effectiveness of the strategy and feedback from the Lab activities. Table 1 reports, according to the self-evaluation table carried on by Lab leaders, the outcomes of the Champions team indicators after both the I and the II round of workshops (planned workshops to be carried on after the present report deadline, and their expected results, are marked *in Italic*).

According to the outcomes of the II Workshops round (and planned activities for the Workshops to come) we observed a significant improvement in the areas and indicators with a deficit in the previous round of workshops. Advances were particularly significant in terms of the definition of sustainable Basin Determined Contributions (BDC) and transformational adaptation strategies (*Where do we want to go* and *How do we get there* in the Talanoa Dialogue framework).

The Champions Team has demanded lab leaders to gather additional feedback from stakeholders in terms of the research activities conducted by the Consortium. To this end, the workshop summary template and the Champions indicators have been revised to include explicitly stakeholder suggestions towards activities conducted in WPs and tasks, with the goal of stimulating partners to further interact with stakeholders in the forthcoming rounds of workshops.

Based on preliminary outcomes of the second workshop round, the revised stakeholder engagement approach designed by the Champions Team proved to be an effective way (together with indicators monitoring) to incorporate users' feedback in the Talanoa Dialogue. For example, the ITA lab identified additional Stakeholders communication channels for dissemination and incorporated a climate change impact model for hydrology developed by one of the Stakeholders; the FRA lab enlarged participation to underrepresented categories; the ESP Lab revised the serious game and incorporated a modeling tool used by the river basin authority into the modeling framework; the LEB Lab adapted and implemented its first serious game and involved more female representatives in the 2nd workshop; the TUN lab also adapted and implemented its first serious game, which was highly instrumental in collecting stakeholder feedback on adaptation strategies to water scarcity. The EGY Lab, whose II workshop is planned at the end of June, identified two additional adaptation strategies (Improving crop water productivity through efficient irrigation systems such as Hybrid Irrigation; and implementing long-term water resources planning via water accounting).

Overall, all labs have managed to achieve strong and continued stakeholder engagement and active feedback. Labs have also managed to mainstream the TALANOA-WATER modeling framework into the assessment conducted by stakeholders and gather feedback on this modeling framework and the results as well.

Future assessments by the Champions Team will take place again during the third and fourth year and will include an assessment of the ability of the project research and applications to be sustainable beyond its lifetime, by means of initiating fundraising activities and building lasting dissemination initiatives that maximize the project's impact also after the project ends.

1.5. Some Possible Concerns and Limitations

Those interested in implementing the stakeholder engagement methods fielded by TALANOA-WATER elsewhere need to be mindful of some limitations of Talanoa Dialogue, its research validity and reliability.

First and foremost, the Talanoa Dialogue builds on trust, so it is necessary to establish trustworthiness among the researchers/practitioners and stakeholders. Through the information gathered in the Talanoa dialogue and meetings, participants may challenge other group's views, and researchers will need to make a discretionary judgment. It is important that this judgment is transparent, as well as the reasons behind it, to ensure no bias is perceived and participation is not affected.

Planning many rounds of workshops and interactions with stakeholders enhanced understanding and evidenced limitations, for which *corrective action* had to be taken in between workshops/other interactions.

For example, after first rounds of interaction a few shortcomings emerged, i.e., underrepresented stakeholder groups (such as farmers in the French Laboratory) or key stakeholders missing (such as public officials) in the dialogue, or gender imbalances (Tunisian and Spanish Labs). To address this gap, corrective action was necessary, including a review of the reporting tools to the Champions Team used by Lab leaders, so as to accurately measure progress in some key aspects. As a general consideration it is necessary to maintain a proper balance in interactions to avoid overstressing Stakeholders and ensure their continued participation. In fact, ensuring a continued interaction is a primary concern of TALANOA-WATER that is addressed through tailored exploitation and dissemination, active stakeholder engagement by means of both direct/indirect interaction and tools such as polls, serious gaming (for which a specific training session has been activated during the first General Assembly held in Montpellier in December 2022), and miro boards, *inter alia*.

The Champions Team has been set up to ensure that the Talanoa Dialogue takes into account the feedback received from the stakeholders. To this end, all labs are tracking the dialogue outcomes through written means (minutes, fact sheets), monitoring indicators (see previous section - Champions Team) and finally by following explicit suggestions towards WPs and tasks. Based on preliminary outcomes of the second workshop round there are some specific suggestions that need to be incorporated in the next round of workshops, such as improving communication, refining serious gaming and multi modeling outcomes (ITA Lab), refining water demand modeling (FRA Lab), achieving a more realistic representation of adaptation strategies (ESP Lab), including some missing key representatives such as those from the Ministry of Energy and Water and the Ministry of Environment as well as NGOs representatives (LEB Lab). In the case of Djeffara (TUN) lab, the list of participants requires a refinement to eliminate non active ones and add new active stakeholders. In addition, it is planned to improve the serious game in the following workshop round to include the modeling results for the main transformational adaptation strategies agreed during the second round of science policy workshops. In that regard, one of the main limitations that should be addressed is how to mainstream the different and complex modeling techniques used by partners into the different contexts existing in each lab, and to reproduce modeling results in a simple and easy-to-understand way through serious games, which will need to be adapted in turn. Training (e.g. serious game training in Montpellier in December 2022 and in Salamanca in May 2023) will support this process and catalyze dissemination among stakeholders and the society. Finally, EGY Lab needs to work on implementing adaptation strategies to enhance crop water productivity of rice, the predominant cultivated crop in the Nile Delta.

2. The Talanoa Water Dialogue and The Underpinnings of the Development, Implementation and Advancement of Transformational Adaptation

TALANOA-WATER aims at informing and catalyzing the adoption of robust transformational adaptation strategies to water scarcity in the context of climate change. These strategies align with the objectives of Integrated Water Resources Management (IWRM), encompassing social equity, economic efficiency, and environmental sustainability. Specifically, TALANOA-WATER explores transformational adaptation strategies that combine complementary and mutually reinforcing approaches. These approaches include (1) nature-based solutions (e.g. natural water retention), (2) technological innovation and climate/water services (e.g. non-traditional water sources, irrigation services advising the timing and intensity of irrigation and optimal protection of crops against extreme climate events), (3) risk management and financing instruments (e.g. payment for ecosystem services, insurance) and (4) economic and behavioral incentives (e.g. water charges, water markets, voluntary agreements). To guide the TALANOA-WATER dialogue process, a set of essential questions will be answered based on the unique conditions and strategies adopted in each water lab (Figure 1).

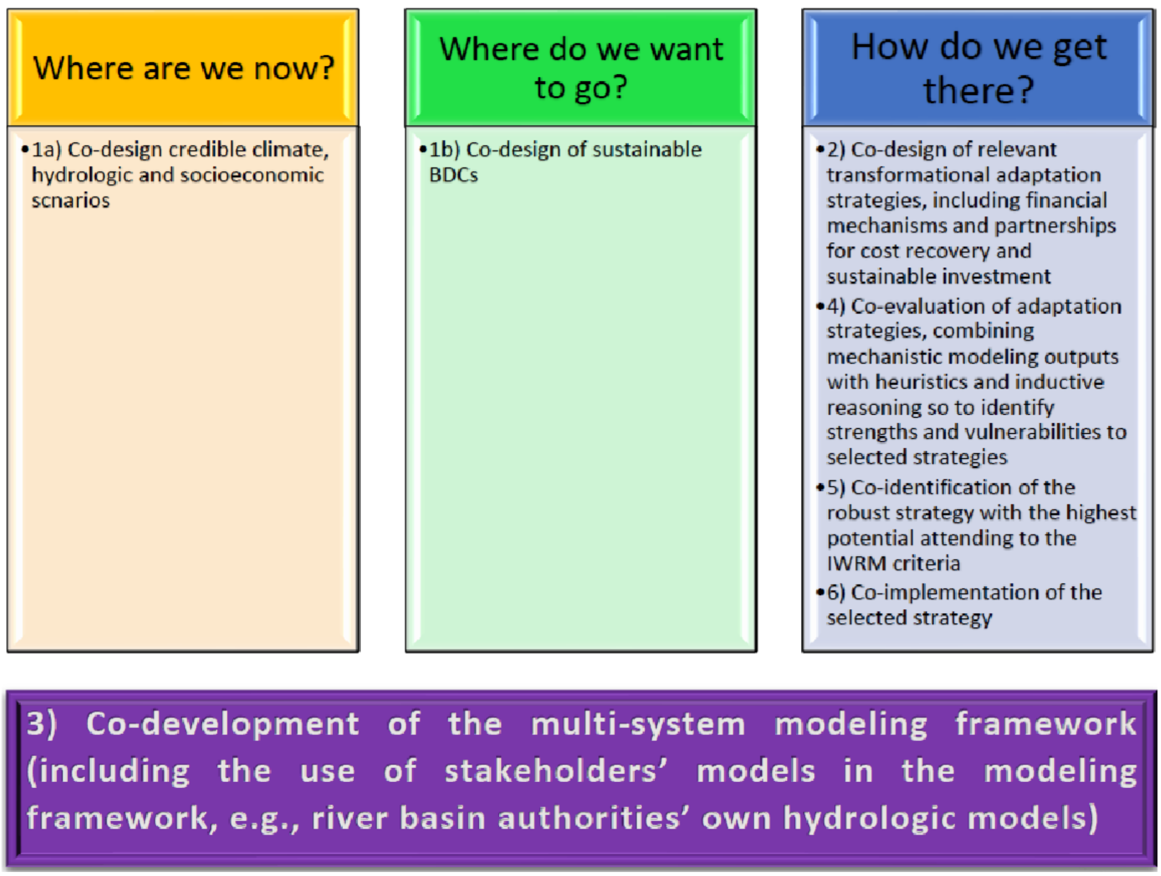


Figure 1. The three guiding questions of Talanoa dialogue to be answered by each lab based on its conditions and adopted strategies

By summer 2022, all the labs successfully engaged with stakeholders in the first science-policy workshop. During this workshop, researchers framed and began developing the activities within each lab following the TALANOA dialogue structure described earlier. The first round of interactions served to clarify the objectives of the lab activities, define the roles of the participants involved, address challenges, and initiate the process of identifying possible solutions and tools.

By Spring 2023, most of the labs conducted their second science-policy workshop. During this workshop, labs presented the initial results of socio-hydrology modeling, serious game, and exploratory evaluation. Additionally, efforts were made toco-identify adaptation strategies for water management issues specific to each lab's area of interest. The outcomes of this first interaction, along with ongoing and future interactions, will be included in the next release of this Deliverable (Talanoa Dialogue Report III).

Below we report the main advances in each lab, streamlining the activities according to the 3 guiding question of the TALANOA DIALOGUE:

- Current Status: Assessing *Where We Are*
- Vision and Objectives: Defining *Where We Want to Go*
- Strategy and Action Plan: Path to Success, *How do We get there.*

2. Water labs

2.1. Spain

2.1.1. Current Status

The Spanish Water Lab is the Cega River Sub-basin. The Cega lab is located within the Douro River Basin (DRB), the larger river basin in the Iberic Peninsula, in the central Spanish plateau.

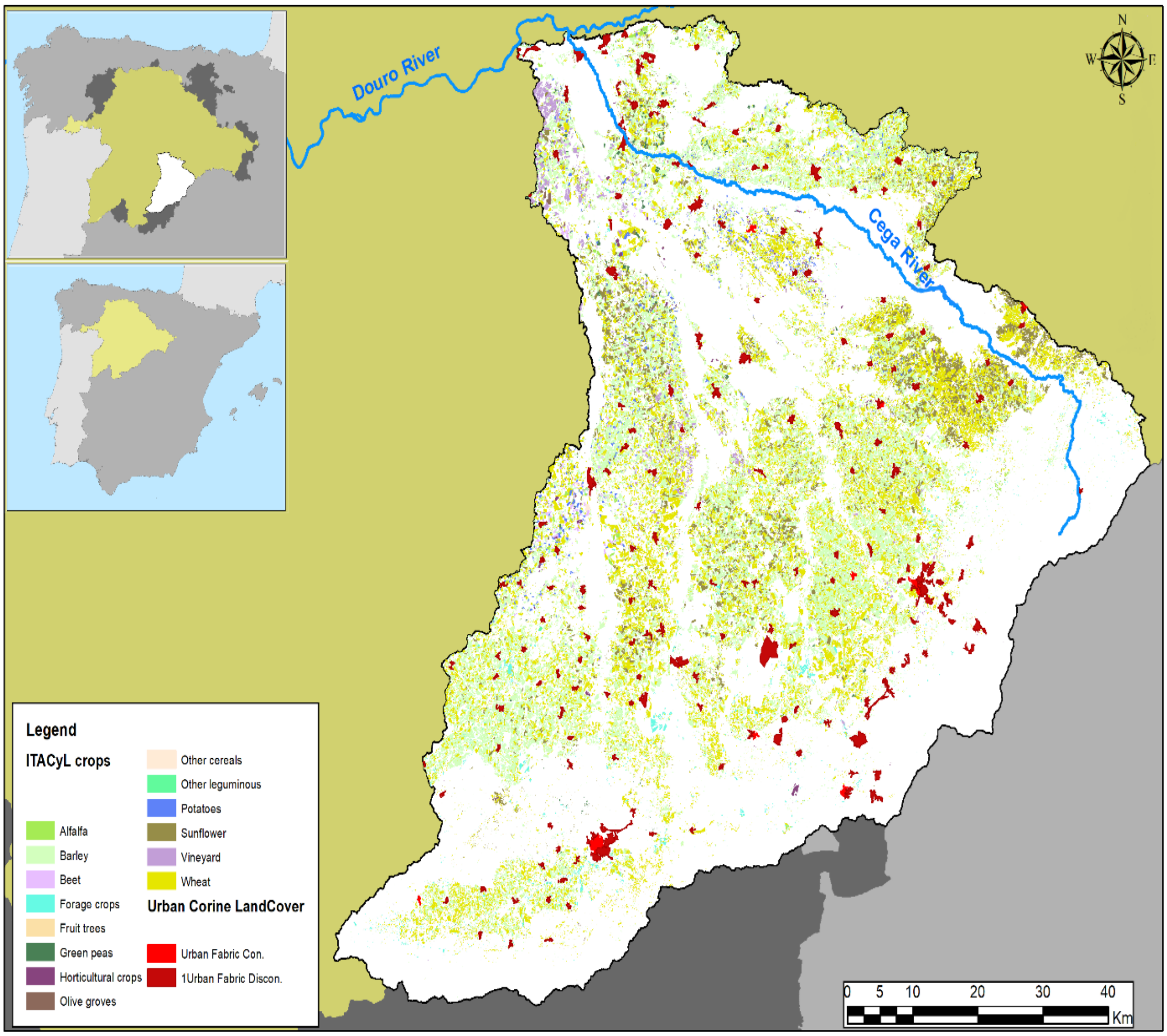


Figure 2. Agricultural and urban land use in the Cega lab.

The area is characterized by a Mediterranean climate with rigid (frequent sub-zero temperature) and wet winters, and dry and hot summers. The average temperature ranges between 8ºC and 13ºC and the average rainfall over the period 1940-2017 is 495.49 mm/year, with an average ET of 421.18 mm/year (DRBA, 2021). If we compare the historical time series (1940-2018) with a more recent and shorter series (1980-2018) we can observe a significant decrease in rainfalls (-4.1%), and an increase in the average temperature of 0.3º C, consistent with climate change predictions for the area (DRBA, 2021).

The lower and middle stretches of the Cega Catchment comprise some of the most productive irrigated areas in the Douro River Basin, featuring high value-added horticultural crops such as carrots, garlic, onion or leek (21% of irrigated surface), whose profits range between 3,528 and 8,679 EUR/ha—significantly higher than the 137 to 252 EUR/ha obtained from cereals, which are the main crop in the region (MAPA, 2019). Other relevant crops in the area include potato, alfalfa, sugar beet, wheat, barley and sunflower (see Table 2). Despite its relative water abundance, the Cega is a non-regulated river, and its volatile streamflow is insufficient to meet irrigation demand—particularly during drought years. This has led farmers to rely on the local aquifer of Los Arenales for water supply, both formally and informally (WWF, 2020). Los Arenales is a complex dendritic aquifer with a large water stock, which has allowed agricultural water withdrawals in excess of renewable resources for decades, leading to decreasing piezometric levels and growing concentrations of pollutants. Altered water flows due to over-abstraction have also caused recurrent peaks in arsenic concentrations in the aquifer, which constrain the local population to rely on tankers for urban water supply (DRBA, 2020). Back in 1998, the regional government declared the aquifer a "vulnerable" water body (BOCyL, 1998), and its ecological status since has been consistently deemed "poor" (DRBA, 2012, 2016a, 2020).

Attempts to recover the good ecological status of groundwater bodies and restore urban and agricultural water supply include treatment plants to remove pollutants in urban areas, and the development of artificial groundwater recharge, notably through the Carracillo Groundwater Recharge in Tierra de Pinares, which has been welcomed by local irrigators and opposed by local municipalities like Gomezserracín.

Another key challenge in the area is flood risk. The Cega River does not have any regulation infrastructure that substantially modifies its flow regime, and the river stretches downstream the Lastras de Cuéllar Dam construction site periodically experiencing flood events. 7 major flood episodes have been recorded in the area in the years 1948, 1961, 1962, 1966, 1996, 2013 and 2014, all of which exceeded a maximum daily flow of 90 m^3/s (more than 23 times the average annual flow of 3.8 m^3/s). The largest flood event was recorded in March 2013, and reached a peak flow of 250 m^3/s (DRBA, 2016b). Areas damaged by floods have been largely agricultural, albeit urban areas have been affected as well, particularly in 2013 and 2014, where small parts of the towns of Viana de Cega and Mojados were flooded. Despite the relatively favorable climate projections that predict a reduction in the frequency and magnitude of flood events in the Cega Catchment (Mentaschi et al., 2020), this risk has become a relevant political concern following the 2013 and 2014 events in the area.

Crops	Irrigated area (ha)	Rain-fed area (ha)	Gross Margin of Irrigated area (EUR/ha)	Gross Margin of Rain-fed area (EUR/ha)
Carrot	1 965	-	3 528	-
Garlic	633	-	8 679	-
Leek	664	-	8 215	-
Onion	406	-	5 849	-
Maize	1 668	-	708	-
Wheat	7 452	69 274	252	247
Barley	10 284	92 388	137	127
Alfalfa	1 015	104	3 956	2 628
Potato	3 587	-	6 191	-
Sunflower	1 400	22 202	221	129
Sugar Beet	2 356	-	1 519	-
Wine grapes	1 326	4 298	2 579	576
Other crops	7 644	44 126	-	-

Table2. Agricultural land use in 2020 and average gross margin (2004 - 2015) in the Cega lab: irrigated and rain-fed crops (DRBA, 2016a; ITACyL, 2019; MAGRAMA, 2020; MAPA, 2019)

To address the challenges above, the TALANOA-WATER project has engaged several stakeholders. As of now, the stakeholders have been identified and a rapporteur from the Douro River Basin Authority identified. The stakeholders gathered during the first project workshop in Salamanca on 29-30 September 2022 at Palacio San Esteban. During the first months of the project, stakeholder engagement remained a priority for the Spanish lab and several additional stakeholders joined the project. Table 3 displays the original stakeholders identified at the beginning of the project and the ones that have joined TALANOA-WATER project afterwards.

2.1.2. Vision and Objectives

The main challenge of the Spanish Water Lab is represented by the increase in water demand driven by the expanding horticulture, mainly supplied with groundwater, which is causing the depletion of the deep aquifer. The adaptation strategies proposed (dam construction, managed aquifer recharge), while supported by local irrigators, have led to significant opposition from local municipalities, citizen platforms, and environmental groups. This has led to conflicts related to the deteriorating quantitative and qualitative status of water bodies (especially groundwater bodies) in the area caused by agriculture (fertilizer and pesticide non-point pollution) and the overexploitation of the aquifer (arsenic contamination), as well the new planned infrastructures (the dam of Lastas de Cuéllar and the managed aquifer recharge in the Carracillo area). Most recently, and despite the positive financial and economic assessment, the dam construction project has been eventually excluded from the draft river basin management plan at the discretion of the river basin authority (DRBA, 2020).

Stakeholders identified at the beginning of the project	Douro River Basin (River Basin Authority)
	Ministry for the Ecological Transition (National Ministry)
	FERDUERO (Association of irrigators)
	Hydropower operator [finally excluded - no contract has been awarded]
	AGROSEGURO (Pool of agricultural insurance firms)
	Plataforma Sí a las Fuentes del Río Cega (Citizen platform)
	WWF (NGO)
New stakeholders involved	Diputación de Salamanca (Local Government managing urban supply in the Salamanca province)
	Ayuntamiento de Salamanca (Municipal Government managing urban supply in the Salamanca municipality)
	University of Castille and La Mancha (experts in remote sensing, have applied Hidromore to the Cega lab).
	University of Alcalá (expert in water economics, water management policies)
	iCatalist, Universidad de Alcalá, Universidad Politécnica (experts in water resources management, part of the HLEAB)
	CEDEX (Public Agency) (*pending confirmation*)
	HEYMO Engineering (Private R&D in charge of developing the river basin management plan)
	Ad Hoc Group Water Scarcity & Drought (DG ENV) (*pending confirmation*)
	Technical Office¡ & River Basin Planning Office of the Douro River Basin Authority (River Basin Authority)

Table 3. Lists the original local stakeholders and the new stakeholders added to the project.

Furthermore, water theft is a concerning issue in this sub-basin with the expansion of the irrigated areas and the increase in water use during drought events. To control and manage these challenges a wide use of remote sensing is necessary to identify the areas in which more water is used than it is allowed.

Another crucial issue is the incorporation of the uncertainty analysis in the policy design, since most predictions used for policy analysis are deterministic.

The data used to setup the socio-hydrology modeling framework encompasses the remote sensing data to calculate the amount of water used in the sub-basin and climate data obtained from an ensemble of prediction models from ISIMIP and CMIP6, as well as microeconomic and macroeconomic data to run economic simulations. This information is used in uncertainty analyses via ensemble experiments to inform the decision makers and allow them to design policies capable of dealing with the changing conditions of climate and water availability under the most plausible futures (i.e., robust). The remote sensing data was already produced with the application of the HSEB model (Jaafar et al. 2022) and Hidromore (conducted by University of Castille la Mancha) in the study area. In a next step, the information obtained will be crossed with the allocation data already available from the basin authority to obtain information on formal and informal abstractions. Climate, hydrologic and socioeconomic data has been also obtained and validated.

Data was used to run a series of preliminary simulations in the lab with a hierarchy of coupled human and natural system ensembles, which was used to assess the consequences of climate change (climate system, hydrologic system) and adaptation (human system) over time in the lab. The modeling framework coupled multiple ecological and human systems building on ensemble experiments (AgMIP, 2022; CMIP6, 2022; ISIMIP, 2022) and socio-hydrology hierarchical structures to develop a comprehensive socio-ecological ensemble. Systems within the hierarchy were modelled with multiple models (multi-model ensemble) that were forced with alternative climate and water management scenarios (multi-scenario ensemble). The resultant hierarchy of ensembles was used to explore the consequences of climate change and adaptation under alternative scenarios and models for selected policies (identified through bilateral meetings ahead of the workshop), while accounting for cascading impacts across ecological and human systems.

The results of the modeling framework for the period 2020-2050 were conveyed to the stakeholders leveraging on a serious game (**serious game 1, already reported in D1.2**). Initially, stakeholders were presented the modeling framework, and the climate scenarios considered (identified from previous bilateral exchanges). Next, stakeholders were presented three predefined alternative policies among which to choose. The stakeholder engagement process was dynamic, and the stakeholders had the option to revise their policies every 10 years and propose alternative adaptation policies. As a result of the interaction with the stakeholders, a ranking among proposed adaptation policies was established, and new adaptation policies to be tested in future modeling rounds were identified.

In the 2nd Workshop, new models (microeconomic ensemble) were calibrated and results from simulations adapted into another serious game (**serious game 2**). In this second version of the serious game a board game with cards was adopted. The aim of this second serious game was to assess the differences between simulated farmers' behavior and the actual behavior emerging in the game played by the stakeholders.

A detailed description of the Serious Game Carried on during Spanish lab 2nd Workshop, is reported in Annex II, also to act as inspiring example for other Labs and incoming Workshops.

2.1.3. Strategy and Action Plan

At present, most of the stakeholders have limited knowledge about the effects of climate change on the Cega lab. Climate change predictions produced by the River Basin Authority in the river basin management plan include a single point prediction based on the IPCC scenario RCP4.5 and using a single input data (best estimate from climate change predictions) series to produce the output that represents the average impact per sub-basin (impact per sub-basin was only added in the last version of the plan, in the previous climate change impacts were produced as an average of the whole DRB) (DRBA, 2021, 2016a; IPCC, 2014). The non-inclusion of other climate scenarios and modeling uncertainty in the climatic assessment remains a major limitation of river basin planning in the Douro and elsewhere, especially to deal with the uncertainty related to future predictions. Uncertainty is a key aspect that will be further addressed by TALANOA-WATER in the Spanish and other labs in future simulations.

Moreover, modeling tools have been further expanded to include the models currently used by stakeholders, most notably AQUATOOL, the Decision Support System used by the river basin authority for water allocation. The model has been mainstreamed into the serious game and further updates are planned for future serious games, possibly through a game specifically oriented towards policy makers.

In the past some of the stakeholders have already participated in the development of some innovative approaches to water management, including through the NAIAD, LIFE IP DUERO and RESET projects, and the re-naturalization of the Órbigo River. These projects included dissemination activities such as documentaries, TV programs, workshops, and others. We are building on these relevant outcomes, adding climate change and water availability analysis and their economic repercussions, to ensure that the information conveyed highlights the critical role of uncertainty. We are collaborating with all stakeholders and particularly the DRB authority and the Ministry for the Ecological Transition, to ensure project outcomes are relevant and replicated elsewhere. Several collaborations have been established with these agents. We are assessing the Mar Menor Plan and are currently implementing the TALANOA-WATER modeling framework in an inspiration lab in the Júcar. Moreover, in the wider Douro Basin where the Cega lab is located, we have established bilateral agreements with the basin authority to use our modeling framework to assess the socioeconomic feasibility of two dam construction projects. Finally, we are informing the current crisis in Doñana through a project with WWF that adopts the TALANOA-WATER modeling framework.

Hereafter we summarize **Key Messages of the 1st Workshop Targeted to WPs** (and specific tasks)

WP1 – ENGAGE

T1.2 The workshop and the serious game have proven to be useful to enhance dialogue and understanding between the different actors. The objective of the serious game has been to carry out a process of dialogue and empathy with the other actors, who have different (sometimes conflicting) interests and views of the problems presented. Another objective was to implement our microeconomic simulations from the study area in the serious game in order to assess the differences between the simulations and the observed stakeholder behavior, so as to validate the model. To this end, a second version of the serious game was developed. The second serious game was played in two different ways: with players adopting their real-life roles, and with players adopting someone else's role. Stakeholders agreed this generated empathy and facilitated dialogue and a healthy discussion among the different stakeholders. This was also observed by researchers conducting the game, and external observers from USAL. Role play serious games will be implemented in future workshops across all labs, and the second version of the serious game introduced to all in a training session during the PSC of Salamanca in May 2023.

WP3 - MODELING

T3.1 The Douro River Basin Authority agreed to mainstream its Decision Support System model AQUATOOL into the modeling framework of TALANOA-WATER. Preliminary simulations with the model have been conducted and results are available in D3.2.

WP4 – LABORATORIES

T4.1 The interested parties suggested possible adaptation strategies such as implementation of insurance for rainfed and irrigated agriculture, more efficient regulation, caps, reallocations, irrigation modernization, investments in the improvement of canals and maintenance of aging dams, make clearer the distinction between surface and groundwater in the game, and the mainstreaming of water pollution mitigation. All but the latter (which falls out of scope of the lab and project) will be addressed in future workshops.

T4.2 Stakeholders have offered to improve the databases with their knowledge in order to calibrate and validate the models used by the Spanish water labs. This has been done already for the hydrologic data that was used to calibrate the AQUATOOL model.

WP5 – EXPLOIT

T5.2 TALANOA-WATER ecosystem of innovation has been adopted and implemented by different international organizations (OECD, European Commission), in the project "Integrated socioeconomic and environmental modeling using remote sensing data for the management of unauthorized water abstractions (IRENE)", and the project "Transformational and Robust AdaptatioN to water Scarcity and ClimatE chaNge under Deep uncertainty (TRANSCEND)". Several inspiration labs have been implemented, including two in Spain: wider Douro and Júcar river basins.

2.2. France

2.2.1. Current Status

The French water lab is located in the Aude department and Aude River basin in Southern France. It includes (among others) two sub basins of the large Aude River basin: The Aude aval ("downstream") and Aude Médiane (intermediary). The Aude aval and middle river basin occupies 3288 km^2 and is located in southern France and has a Mediterranean coast. Its agricultural land use is dominated by wine production (60% of agricultural area and 90% of irrigation area). The location can be visualized on Figure 3. These sub-basins have been chosen because the water deficit between uptake and resource is concentrated there as well as the large majority of uptakes. The challenge set by the water basin management plan (PGRE, 2017) is to save about 30 Mm^3 over 100 Mm^3 that are withdrawn. More than 75% of the withdrawals are for farming. In 2020, the territory of the Aude Médiane et Aval had 5398 farms, the majority of which are vineyards (83% of the farms). There are nearly 121,000 hectares of agricultural land in the territory, this is more than a third of the territory of the basin. In total, 2015 farms are equipped with irrigation systems, for 27,032 ha of irrigable useful agricultural area (UAA). The total UAA is allocated to vineyards (60%), meadows and fodder (27%), fallow land (6%), cereals (3%) and other crops. The irrigated UAA is mainly destined for the cultivation of vines (90%).

Figure3. Location map of the French lab: Aude Médiane & Aval (seashore)

The water management plan (SMMAR, 2017) (or Projet de Territoire pour la Gestion des Eaux, PGRE in French) has been elaborated without accounting for new uses or activities nor with climate change impact on the resource. Resorting to foresight is one of the future objectives of the water authority (EPTB Aude) to revise the PGRE in its next round (from 2023 on) and to align with the objective of the newer instrument PTGE which is in line with some of the TALANOA objectives.

In this area the rain and flow are expected to be reduced. As an illustration water deficit over the crop growth period of wine is expected to reduce from -507 mm to - 543 mm (RCP8.5) or from -521 to -563 (RCP4.5) in the near future (2020-2050)[1]. Temperature increase will also cause an increase of evapotranspiration of soils and crops increasing the water demand of crops.

For the second workshop, simulations were made on the evolution of irrigation water volumes from the crops of the year 2020 in projection for 2050. An increase of water demand for irrigation is expected for all the crops in the different climate scenarios. In particular, the most affected sectors will be the orchards and wine production, with an expected increase between 10 and 20%.

	Water Demand (incl rain) (Millions m3)				Net Irrigation (Millions m3)				Variation 2020-2050, Nac (%)		
Years	2020	2050			2020	2050			2020-2050		
Scenario	-	rcp2.6	rcp4.5	rcp8.5	-	rcp2.6	rcp4.5	rcp8.5	rcp2.6	rcp4.5	rcp8.5
Grassland	2.22	2.24	2.24	2.32	1.53	1.56	1.54	1.67	2.00	0.87	9.31
Olives	1.64	1.64	1.68	1.71	1.00	0.99	1.02	1.07	-1.00	2.13	7.65
Peaches	3.23	3.21	3.30	3.37	0.91	0.92	0.95	1.10	1.19	3.73	20.95
Tomatoes	3.05	3.05	3.16	3.12	1.53	1.52	1.57	1.59	-1.08	2.73	3.75
Durum wheat	0.58	0.59	0.58	0.60	0.24	0.24	0.23	0.26	1.52	-3.86	7.45
Vine	100.44	100.32	102.95	104.03	53.40	52.84	54.52	57.94	-1.05	2.10	8.50

Table 4. Future scenarios of irrigation demand in Aude (preliminary simulations that will be updated)

[1] Source : CANARI climate service Déficit hydrique sur le cycle cultural (mm) | CANARI (canari-agri.fr) for the SAFRAN mesh including Narbonne. This indicator is the cumulative daily water deficit (precipitation - ETP) over the development cycle of the vine, period from April 1 to September 30.

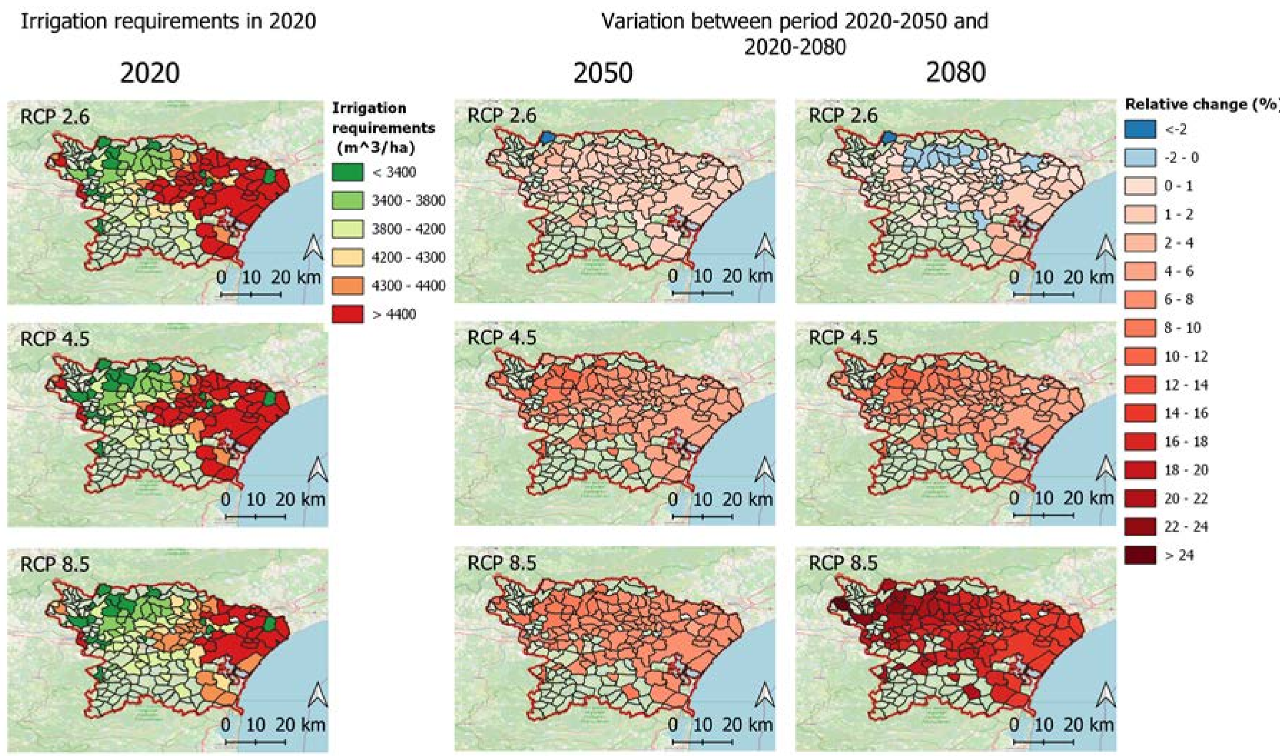


Figure 5. - Variation in crop irrigation water requirement as simulated with the SIMETAW model (preliminary results) 2020-2050, RCP 8.5

The perception of climate change and water stress has increased in the recent past with the 5/7 last year's being a series of relative to severe dry years. Also, a major heat event has been observed during 2019. Late frost risk increases also, notably for wine which is the major crop of the area (earlier bud break makes the plant more advanced when April frost can still occur (example of the early April frost of 2020). This picture makes farming in the area vulnerable to climate change (Table 5).

Level	**(a) Sum of precipitation – RCP 4.5**		**(b) Number of days > 35°C**		**(c) Hydric deficit on the vine cultural cycle**	
	Passé Recent	Future Proche	Passé Recent	Future Proche	Passé Recent	Future Proche
Minimum	140.81	116.20	0.00	0.00	-822.72	-837.62
Moyenne	669.35	647.86	2.91	5.90	-520.92	-563.31
Maximum	1877.23	1592.63	27.00	30.00	31.80	-3.08

Table 5. Extraction from CANARI calculator ("Passé recent": 1980-2020; Futur proche = 2020-2050. Moyenne = mean) – RCP 4.5) Source: https://canari-agri.fr/

The Aude River basin is a complex basin because it is a non-natural river basin because of the major water conveyance infrastructures around the "canal du Midi" with water uses for hydropower production, navigation/recreation, irrigation, drinking water and environmental issues. It is also characterized by inter-basin transfers.

More details are given in the Plan de Gestion de la Ressource en Eau (SMMAR, 2017) that suggest an accounting exercises.

For the second workshop, hydrological simulations were modeled in order to help stakeholders project themselves on future time scales. The Gauging station of the Rebenty at Saint-Martin-Lys has been chosen for assessing the potential evolution of some water resources indicators:

- the minimum flow during 10 consecutive days with a return period of 2 years (VCN10_2)
- the minimum monthly mean flow with a return period of 5 years (QMNA5)
- the inter-annual mean flow (QA)

We have calibrated a rainfall-runoff lumped model with historical data (precipitation, potential evaporation, temperature, observed discharge) and force it with meteorological data from 11 projections for both RCP4.5 and RCP 8.5.

The comparison of these indicators calculated for the period 1976-2005, 2021-2050, and 2041-2070 shows a limited impact on mean flows (QA) and a great decrease of droughts indicators in the future (VCN10_2 and QMNA5) (Figure 6).

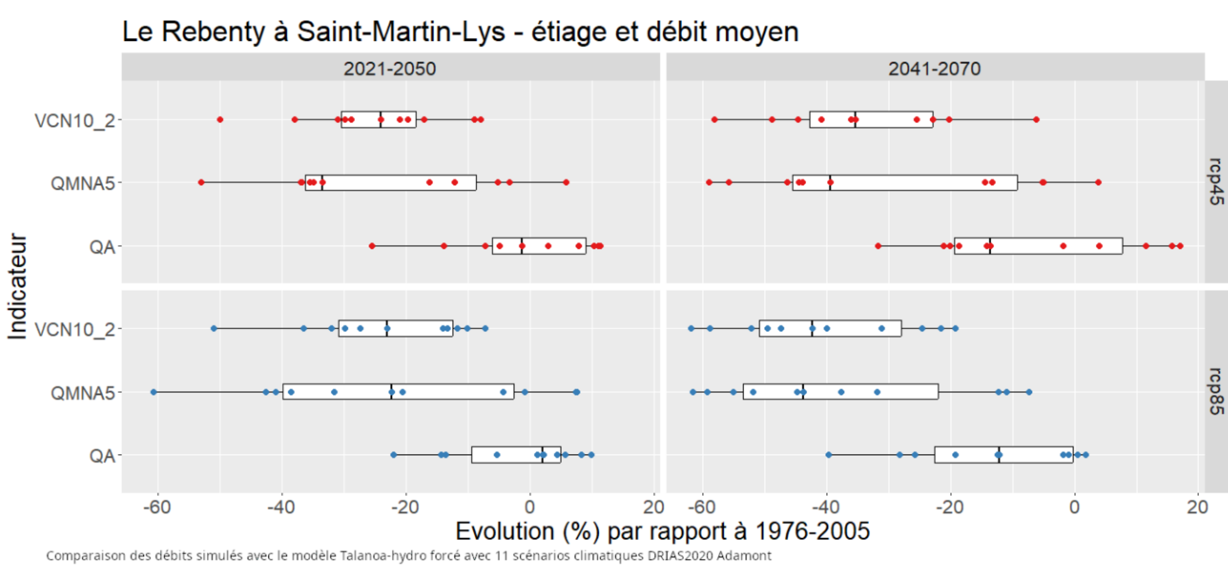


Figure 6. Evolution of hydrological indicators The Rebenty

The stakeholders involved are very diverse and those that are invited are all those that have been identified with having a stake in the water management. The list of stakeholders and their institution is available below: Parties Prenantes TALANOA Aude Public

2.2.2. Vision and Objectives

This question was raised in the first workshop and has been readdressed in detail during workshop II.

As a preamble, we already identify different trajectories that are pursued by different types of actors:

- The trajectory designed by the water management plan (SMMAR, 2017) is to reduce the deficit in the Aude River during the low flow period (~30 Mm^3 over 100 Mm^3 use); already reduced by more than 13 Mm^3 (SMMAR, 2022). The majority of measures correspond to modernization of both water conveyance infrastructures and irrigation technology, but do not involve agriculture.
- Another trend that is observed and which dynamic is continuing is the increase in water demands for irrigation, specifically for vineyards as illustrated by agricultural census between 2010 and 2020. This trend is expected, at least for several actors (but the actual state of winter drought starts to question this development) to continue as illustrated by the different projects of extension in different unions of irrigation associations or by Aquadomitia (regional water conveyance infrastructure) as illustrated in the agricultural water master plan "Schéma directeur d'eau brute" of the Aude department (Département de l'Aude, 2017) and the Carcassonne Agglomeration.
- Another driver or trend is linked to hydropower production, one of the key levees to transform the energy production and mitigate the GHG from this sector. Even if hydropower is a non-consumptive use, the optimization of the production requires that water is retained when some water should be delivered for downstream uses. Some conflicts or at least trade-offs are observed here.

The ambition of the TALANOA dialogue in the French lab is, among others, to question the development of irrigation areas for wine and imagine alternative futures for farming and specifically for water use by farming. Wine has been historically grown without water even in territories that are dryer and hotter while producing food is a rising issue for local territories. Another ambition is to explore the limits of the "more crop per drop" approach or modernization approach that will also reduce recharge to the aquatic ecosystems also known as the 'Zombie idea' (Perez-Blanco et al. 2021).

In workshop II, we produced 4 contrasted foresight scenarios that are illustrative of how the future can unfold. Initial narratives have been written by the researcher team as a local declination from four contrasted SSPs (O'Neill et al. 2017) resorting also to existing foresight exercises that were held locally or on the wine sector (Aigrain et al. 2017).

The interest to rely on locally downscaled SSPs to envision and simulate the local conditions in the agro-hydro-economic model is that the associated RCPs will be used in the hydrological model simulations that need climate data as input. As such coherent climate and socio-economic scenarios will be considered and modeled. These initial narratives have been commented on to reinforce internal coherence by four tables of about 10 participants (1 table: 1 SSP) and derived in terms of context for water management: each table was invited to describe the implication of this scenario in terms of quantitative water management and governance. They were also invited to derive these scenarios in terms of land use changes on four contrasted areas of the territory quantitatively. Table 6 shows the main characteristics of the four contrasted scenarios.

TITLE	**Table 1** ***Regional Ecological***	**Table 4** ***Carbon Liberal***	**Table 2** ***Regional Carbonaceous***	**Table 3** ***Liberal Low Carbon***
Correspondence SSP & RCP	SSP1 - RCP 1,9 / 2,6	SSP5 - RCP 8, 5	SSP3 – RCP 7	SSP4 - RCP 4,5*
Water Management Context	*No water supply development; much agro-ecological*	*Water supply development / little intervention (less regulatory & incentive instruments)*	*Incentive & regulatory instruments, (less agro-ecology)*	*Few structured water supply projects, agro-ecology undergone, few regulatory & incentive instruments*
Major trends Climate	Increase in temperature and in the occurrence of extreme phenomena, reinforcement of droughts. These evolutions will be marked especially after 2050. Divergence of less than 1°C before 2050.			
Estimated temperature (C°) 2040-2060	+1,6-1,7	+2,4	+2,1	+2,0*
Estimated temperature (C°) 2080-2100	+1,4-1,6	+4,4	+3,6	+2,7*
SSP - assumptions of the work taken up by the IPCC	Optimistic human development trends (especially in developing countries), with sustained investment in education and health, rapid economic growth and well-functioning institutions		More pessimistic development trends, with little investment in education and health, rapid population growth and growing inequality	
	Increasing shift to sustainable practices	Energy-intensive and fossil fuel-based economy	Focus on regional security, limiting inequalities	Large inequalities within and between countries dominate

*Table 6. Overview of the SSP scenarios and their correspondence with the PCRs (*the association of PCR 4.5 with SSP4 or here, liberal decarbonized scenario, is an own initiative and not done by O'Neill et al. (2017). The IPCC work seems to have abandoned the latter scenario as being too close in effects to the others.*

2.2.3. Strategy and Action Plan

Some examples of measures that have been identified before the second workshop:

- Optimization of the system, this option resort to improving the efficiency of the whole regulated system. Locally this is known as "compensation" mechanisms: to reduce the effect of a local direct uptake in the river dams release the equivalent volume at the appropriate timing to compensate for the uptake in the stream. This will mask the effect of an uptake on the flow. This system is already operational for some uses/places, but the generalization is currently discussed in the water management plan.
- New resources such as reuse of treated wastewater have already been identified as an avenue by stakeholders to increase water resources. One plant at least is already operational (Roquefort des Corbières) while the second is still at an initial stage (Narbonne Plage for 80 ha). It should not be forgotten that the counterpart is that when water is used from the water treatment plant it reduces the contribution to the flow downstream of the plant.
- The adoption of agronomic practices that save water. An illustrative measure is the one that consists in changing gravity irrigation by drip irrigation. The consumption by the crop is not necessarily modified but the raw withdrawals are reduced, at least in the short term. (The well-known rebound effect can be a second effect that implies the extension of irrigation areas with this stock of saved water. In this case there is a net loss in return flows or recharge for groundwater). Other practices that exist for instance that consist in limiting water evaporation or leakage by addressing soil management (adding organic matter, cover crops…) can be considered, and considered as an NBS.
- The change in crops from intensive irrigation water crops to less intensive water crops is an important levee to transform water demand by farming. This has been poorly explored until now in the basin and is what TALANOA Water ambitions to explore. One example is the trial of the substitution of rice production in the lowlands (25 000 m^3/ha) by quinoa (~500 m^3/ha) that is also tolerant to salt. More practices or trials should be identified.

In workshop II, a specific session (the afternoon session) that took the form of a serious game invited participants to play their real role in the same tables and SSPs as in the previous session. Five rounds were played (i) defining collective objectives for 2050, (ii) stating the measures that are already implemented, (iii) choosing measures for 2025, 2035 and 2050. They were invited to articulate them at 3 horizons and between measures. One after the other they choose some measures belonging to four families (i) new water supplies, (ii) optimize technologies and network, (iii) agro-ecology and agricultural practices and (iv) economic and regulatory instruments and governance.

One of the results that still needs to be confirmed is that transformational adaptations are needed to address water balance between users and resources: concretely speaking land use and agricultural models are to be questioned e.g. the development of irrigation on vines - and that incremental and individual adaptations – e.g. the optimization of networks or technologies - will not be enough in the long term.

After the workshop II, one of the issues is that a high number of measures have been identified (more than 100, among which more than 60 are new measures) on the 4 tables of the afternoon. The next steps (by the research team & in the workshop) will be to continue combining these measures and, likely, to select some to work within the workshops and in the modeling. Here are some of the most cited concrete measures that emerged from the second workshop:

- REUT: Reuse of Treated Wastewater
- Enrichment of soils with organic matter (distillery, STP sludge, shredded vine shoots, green waste compost, etc.)
- Soil cover to limit evaporation.
- Training & improvement of crop management, irrigation
- Suppression of gravity irrigation - Generalization / modernization of drip irrigation
- Reinforcement of SAGE prescriptions (regulations), SDAGE/DCE objectives, PGRE - Adaptation of the volume withdrawn to the volume that can be withdrawn (reduction of withdrawal authorizations)

The finalization of the strategies that will be considered and assessed will be based on feedback between the stakeholder platform and the research team and modeling.

Hereafter we summarize **Key Messages of the 1st Workshop Targeted to WPs** (and specific tasks)

WP1 - ENGAGE

(2) The second workshop aimed at making stakeholders work collectively on socio-economic and climate scenarios applied to their territory according to different, more or less restrictive, trajectories. It brought together 27 stakeholders involved in the participatory approach, including actors already involved in Talanoa but also new actors from targeted contacts, the workshop on agroecology (27/02/2023) and/or the network of actors in the territory. It can be noted that 15 people/organizations present at this workshop were already present at the first workshop in 2022. The remark that

followed the first workshop on the presence of farmers or structures representing the agricultural world was heard and respected: increasing from 5 to 11 representatives for this edition. The profile of the participants was varied and allowed a heterogeneous representation of the territory.

For future meetings, special attention should be paid to the participation of representatives of fisheries and the environment, who were under-represented or even absent in this workshop.

Consideration should also be given to involving elected officials in the process: define when and in what form.

WP3 - MODELING

(1) Presentation of the different scenarios & hydrological simulations and water demand of crops on the territory by INRAE researchers involved in Talanoa. Discussion with the stakeholders on the coherence, feasibility and limitations of the projections.

Several points were raised and made it possible to refine/adjust the scenarios to be more in line with the reality on the ground.

One of the objectives for the next workshop will be to develop a simplified ready-to-use model to assess, quantitatively, the water demand resulting from scenarios and understandable by all and that would give indications on the availability of the water resource according to the choices and trajectories of the stakeholders.

(2) Participants, particularly farmers, were invited to share their stories and feelings about the 2022 drought at this workshop in the form of anonymous stories or testimonials. Unfortunately, this initiative did not generate any feedback.

The scenario thinking exercise was oriented around four main categories of actions: agro-ecology and agricultural practices / water resource development / resource optimization / regulatory, incentive and governance instruments. The actors had the choice to propose measures according to these categories in a more or less coordinated way between the different parties (farmers, water managers, communities, state services, insurance, researchers).

These measures made it possible to collect data that will be useful for guiding economic, hydrological and agronomic models, particularly on the decisions made by the stakeholders (agricultural practices, water use, etc.).

WP4 - LABORATORIES

(2): In order to better understand and take into consideration sustainable, environmentally friendly and water-saving agricultural practices in the measures, the team organized a workshop dedicated to agroecology before this day. The objective of this workshop (27/02) was to present the results of a student project within the framework of Talanoa entitled "Which agroecological practices and which associated support systems to cope with water stress in the median and downstream Aude basin", to share knowledge and good practices on these subjects.

Thus, the results of this workshop could be transcribed in the preparation of workshop II (March 9) and allowed the actors who were able to attend the two events to broaden their spectrum of solutions to be implemented on the territory.

In order to continue the reflection on agroecological practices, it is envisaged to organize another thematic workshop combining theory and practice, with a field visit and feedback for farmers.

WP5 - EXPLOIT

(2) Several communication tools are used with stakeholders depending on the type of information to be shared. These different channels allow us to reach a diversity of actors and their networks:

- *Emails are the main "official" communication tool.*
- *The website allows to share regular news about the project.*
- *The Facebook group allows for informal exchange of knowledge and ideas between actors.*
- *LinkedIn personal accounts and Twitter are used to relay information.*

2.3. Italy

2.3.1. Current Status

The area of interest lies within the Emilia Romagna Region (RER), situated along the southern border of the Po River District Authority (Figure 7). In Italy, laboratory (Lab) activities are concentrated at a local level on the upper Secchia River catchment within the provinces of Modena and Reggio Emilia. In this region, the availability of water resources is not only crucial for the sustenance of aquatic life and the preservation of the natural environment, but also significantly contributes to human quality of life and economically significant activities.

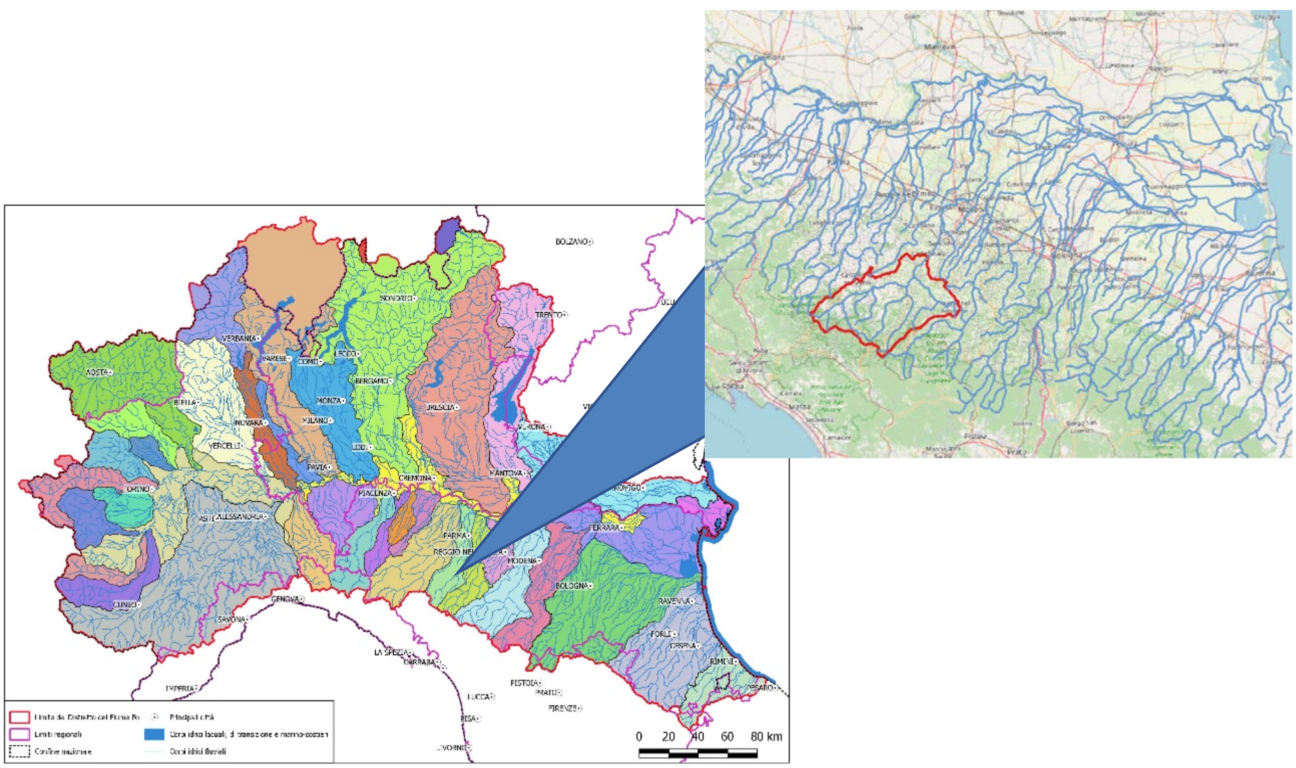


Figure 7. Location of the study area in RER- Italy, south of the Po River District, in the upper provinces of Reggio Emilia and Modena

The catchment is situated upstream of the Castellarano Weir (Figure 7), an area where water usage spans various sectors, including agriculture, industry, hydropower generation, and river body surveillance and conservation. The local climate in this area is warm and temperate, with significant rainfall recorded throughout the year. The Regional Climatic Atlas (ARPAE, 2017) consolidates data and findings from the regional monitoring network, detailing shifts in climate conditions between 1991-2015 compared to the previous 30-year reference period (1961-1990). Specifically, the regional average temperatures rose by 1.1 °C (+1.4 °C for maximum temperatures, +0.8 °C for minimum temperatures), while the annual rainfall decreased slightly by 22 mm (-2%), albeit with notable seasonal fluctuations, such as drier summers and rainier autumns.

Figure 8. A view of the Weir at Castellarano along Secchia River

Hydrological regimes are highly torrential. During the summer period, in the months of July and August, the natural flows are at about 15-20% of the annual averages.

With regards to the supply and utilization of water resources, the most recent comprehensive data, encompassing both availability and demand, are available up to 2011. These figures are derived from the previous iteration of the regional water balance, which is currently under review (ARPAE, 2015). Table 7 presents the water availability, water needs for maintaining ecological river flow (also currently under review), and water exploitation. Despite the data being somewhat dated (circa 2011), the situation in the main catchments within the study area is evident. There is a noticeable reduction in water availability compared to climatology, which corresponds with increasing pressures on water bodies.

main hydrological quantities restimated with regional models

River	station	Water body	Area (km2) (km²)	Hmed m slm	annul precip. (mm/y) 32-90	annul precip. (mm/y) 91-01	annul precip. (mm/y) 02-11	Av. Flow Qm (m³/s) 32-90	Av. Flow Qm (m³/s) 91-01	Av. Flow Qm (m³/s) 02-11	Variation of flow '90-01 Vs '32-'90	Variation of flow '02-'11 Vs '32-'90
F. Secchia	Castellar	012000000000 7	952	830	1262	1189	1204	24.6	21.1	20.9	-14%	-15%

Average annual outflows 2002-2011 and resources available at the

BM: mountain basin – Asta	Areale	Water body	station	Area (km²)	minimum flow Oct-Apri, May-Sept. – Qm	DMVi	DMVe	annual flow (Mm³/y)	max exploitable flow (m³/s)	availble resource (Mm³/y) Oct-Apr	May-Sept
Secchia	BM	012000000000 7 ER	Castellarano	952	16.5	1.94	1.28	521	7.5	114	28

Main alterations to natural outflows at the exit of the

Water body codes – Code	Name	station	Catch. Area (km²)	drained water bod.	Dishcarges (Mm³/y) Civil	Dishcarges (Mm³/y) Industrial	Withdrawals (Mm³/y) Civil	Withdrawals (Mm³/y) Industrial	Irrigatio	farming	others	Hydropower (Mm³/y) withd.	Hydropower (Mm³/y) release	Changings (m³/s)	avg. Flow (m³/s)
012000000000 8	F. Secchia	Valle Sassuolo	1028	31	4	0	-10	-2	-19	0	-2	-1020	1020	-0.91	21.89

Table 7. Synthesis of water availability, ecological needs, and exploitation for the main catchments in the area

The obligation to maintain the minimum ecological flow downstream of the withdrawal often leads to critical situations due to the inadequate availability of irrigation resources. The expected **climate change impact on water resources** availability and exploitation is shown in Table 7 .

A recent report on regional climate projections for homogeneous areas from ARPAE (2020) offers insights into precipitation and temperature trends, factors that significantly influence water generation and availability. The primary area of interest for the lab largely falls within the "West hill" region, for which the following table summarizes the projected values.

While detailed projections on the impacts of such changes on water regimes are not available, general projections for the Region are provided in ARPAE (2017) for the RCP4.5 emission scenario. This scenario anticipates a reduction in greenhouse gas concentrations over time, following the adoption of mitigation policies.

Ref.Period	1961-1990	1961-1990	1961-1990	1961-1990	1961-1990
Climate projection.	**2021-2050**	**2021-2050**	2021-2050	**2021-2050**	**2021-2050**
Em. Scenario	RCP4.5	RCP4.5	RCP4.5	RCP4.5	RCP4.5
Indicator	**AV. Annual temp.**	**Max Summer temp.**	**heat waves**	**Annual perc.**	**summer dry days**
Description	average daily	average daily max	numb of consecutive day with temp above 90th Percentile	total cumulate	Numb. of consecutive days with prec. below 1 mm
Unit of meas.	[°C]	[°C]		[mm]	-
value ref. period	10.9	25.2	3	1020	20
value clim. Project.	**12.6**	**27.7**	**8**	**940**	**26**

Table 8. Climatic projections for water availability related variables, emissive scenario RCP4.5 in the area of interest, source (ARPAE,2021)

The climate scenarios for the region demonstrate significant indications of change for the period 2021-2050 compared to the reference period of 1971-2000, both in terms of temperature and rainfall. For the period 2021-2050, there is a likely increase in minimum and maximum temperatures of about 1.5 °C in winter, spring, and autumn, and about 2.5 °C in summer.

There is also a probable increase in temperature extremes, including heat waves and tropical nights. A probable decrease in the amount of precipitation, particularly in spring (around 10%) and summer, is anticipated, as is a probable increase in total precipitation and extreme events in autumn (about 20%). Furthermore, there is an expected increase in the number of consecutive days without precipitation in the summer (about 20%).

The expected changes will affect both water needs and hydrological and hydrogeological processes, and the availability of water resources, as suggested by the Regional Report on Climate Change Mitigation and Adaptation Strategy (RER, 2018). Climate change could indeed alter the seasonal distribution and variability of rainfall and temperature, inducing significant variations in water availability.

A recent synthesis report from the regional observatory on climate change (RER, 2019) provides a valuable overview of the expected impact of climate change on the economy. We will focus on the impacts most relevant to the Lab area.

The Regional Rural Development Plan (PSR) for 2014-2020 qualitatively outlines how climate change will impact the related **agricultural** sector. It predicts an increase in water consumption, higher concentrations of pollutants in groundwater and surface waters due to pollutant losses following extreme events, potential degradation of soil organic matter, proliferation of invasive alien species, and the emergence of new adversities for plants and animals.

The **production** sector is also experiencing the effects of climate change, especially in terms of business interruption. This category considers disruptions in production or service provision, primarily due to issues such as the supply of raw materials (in this case, water as a part of the production process) or energy. Furthermore, the damage that climate change inflicts on agricultural production has repercussions on the agro-industrial sector in terms of discontinuity in activities.

Figure 9. Run of River hydropower plant along upper Secchia River in the area of interest.

The **energy** sector is another significant economic area that's particularly vulnerable to climate change. Indeed, with the global average temperature rise, the demand for energy will shift - less will be needed for space heating, while more will be required for cooling. In general, a substantial increase in electricity consumption is anticipated during the summer season. The escalating use of air conditioning systems could lead to a higher risk of blackouts.

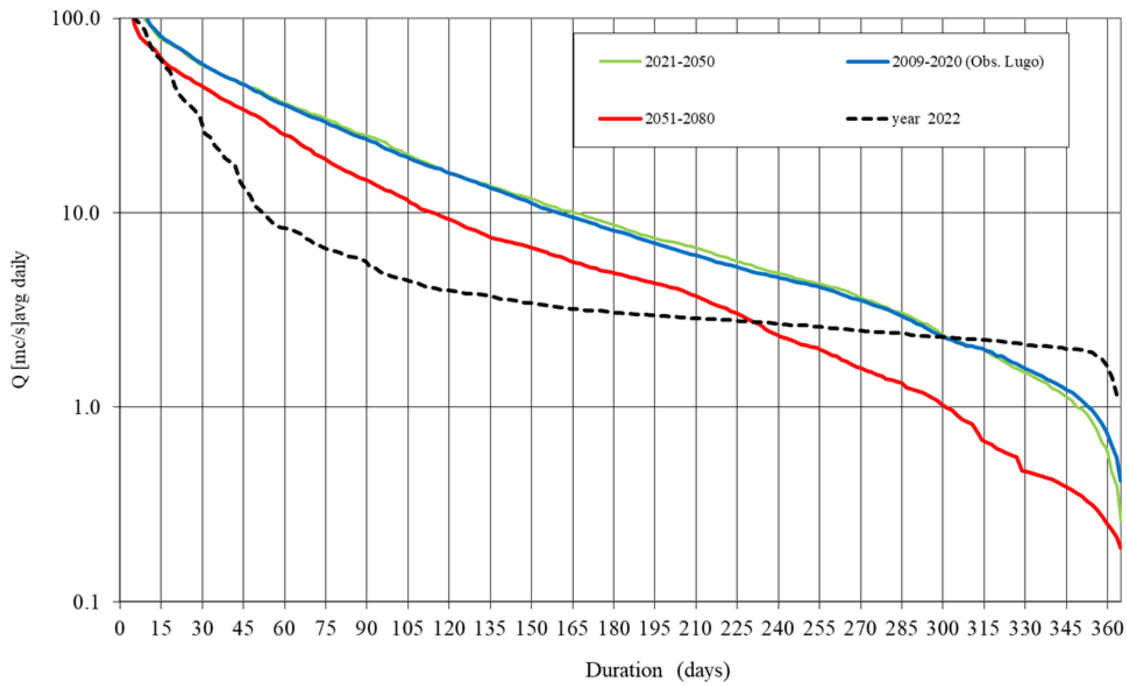
The production and supply of energy will also be affected by the likely decrease in water resources available for hydroelectric production or for the cooling of thermoelectric plants. Additionally, for the hydroelectric sector, increasing focus will be needed to preserve the ecological conditions of watercourses. This involves ensuring an appropriate discharge from plants throughout the year and managing conflicts related to other uses of the resource (Figure 9).

During the second workshop round, we shared and discussed the results of local hydrologic modeling on the current status of the resource in comparison to expected climate projections (RCP 4.5) with stakeholders.

This detailed information was obtained by downscaling modeled discharges provided by the Environmental Agency ARPAE (a stakeholder in the Lab) and CMCC (Vezzoli et. al, 2014), using local historical data recorded at the ARPAE discharge monitoring station "Lugo", located upstream of Castellarano Weir. Climate change projections for RCP 4.5 indicate a significant modification in the flow regime, as evidenced by the lowering of Flow Duration Curves (FDCs) and the decrease and shift of average monthly availability, as illustrated in the subsequent figures. This data prompts discussions on possible adaptation strategies to manage demand, particularly during the dry season.

Figure 10. local discharge monitoring station used to downscale results of ARPAE-CMCC hydrological model.

Climate Change projections for RCP 4.5 show a considerable modification in flow regime (detected in lowering of Flow Duration curves FDCs and by lowering- shifting of average monthly availability) as shown in the following figures. that triggers reasoning on possible adaptation strategies to cope with demand, particularly in the dry season.



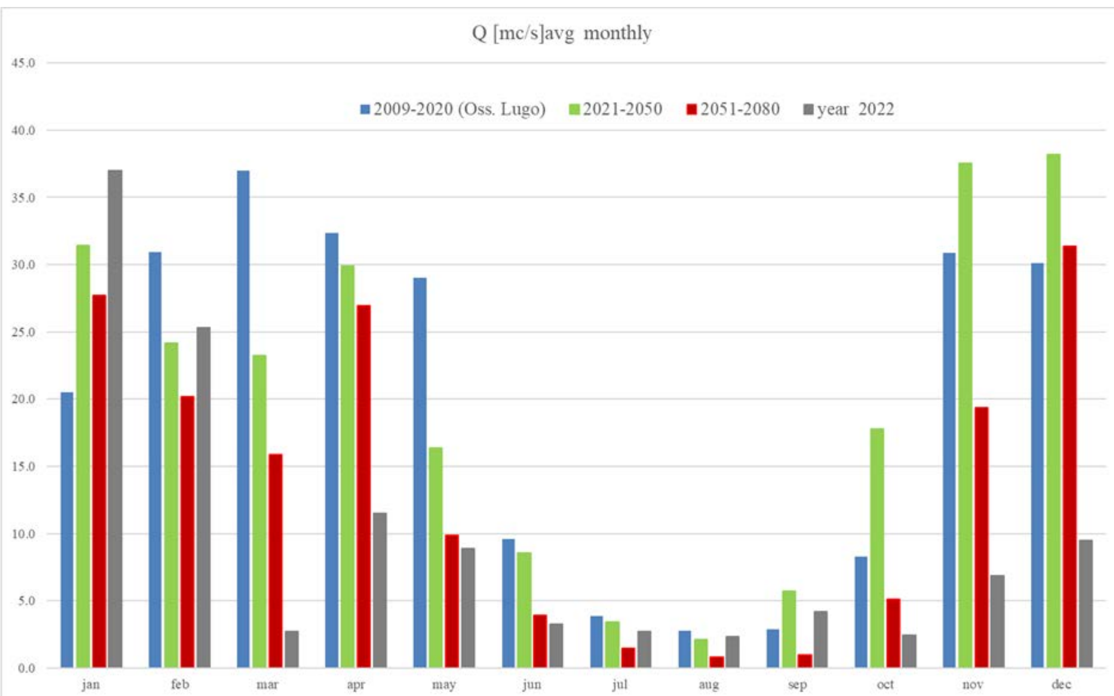


Figure 11. local discharge projection in RCP 4.5 (FDC above and monthly values below) downscaled to the closer monitoring station.

The existing stakeholder group aptly reflects the core interests and challenges in the Lab area, encompassing key players from the water sector. The regional government is represented by the Directorate General for The Care of the Territory and The Environment, and the Service for The Protection and Remediation of Water, Air, and Physical Agents. These bodies oversee the regional government's actions concerning water resources across the entire region, striving towards a sustainable future, developing the Regional Water Protection Plan, and contributing to Water District Management Plans.

Regional multi-utility companies are represented by IRETI Spa, which oversees the integrated water service in 242 municipalities of Emilia Romagna (provinces of Parma, Piacenza, and Reggio Emilia). IRETI manages a multi-use aqueduct that serves industrial, irrigation, and fire-fighting users. It was constructed with regional funding in the 1980s with the objective of preserving underground aquifers for potable water.

Land Reclamation and Irrigation Consortia, which are major actors in providing water to agriculture (a significant economic sector in the region), are also part of our group. We have onboarded the Burana Consortium, which covers more than 240,000 hectares of territory across 50 municipalities, and the Emilia Centrale Consortium, which distributes water for irrigation and environmental purposes to an area of approximately 120,000 hectares during summer. They also manage the hydropower plant at the Castellarano Weir, with an estimated average energy production of 6 GWh/year.

The private sector is represented by Aren Electric Power Spa, a company active nationally in energy production using natural, renewable, and sustainable resources (wind, solar, and hydro) with over 85 megawatts of installed power. In the Lab area, they manage the hydropower plant just upstream of the Castellarano catchment (near the regional monitoring station named “Lugo”), with an installed capacity of 3.2 MW and an expected annual clean energy production of around 11 GWh/year.

The Regional Environmental Agency ARPAE is another key actor in the water sector, responsible for maintaining the monitoring network, which includes hydrological and meteorological gauging stations, and providing climate projections for the regional government. As part of the Regional Observatory on climate change, ARPAE is instrumental in environmental monitoring and forecasting. Lastly, ARPAE is in charge of issuing and revising withdrawal permissions for all users when necessary.

2.3.2. Vision and Objectives

At this stage of the Lab's activities, following the first and second workshop rounds held between July 2022 and March 2023, the primary topic of investigation has been identified as the water availability from surface resources. This includes an examination of the water balance in the catchment area closed at the Castellarano Weir, with a particular focus on drought conditions, as demonstrated by the exceptionally dry summer season of 2022 (refer to FDC in Figure 11). Additionally, other periods of interest for possible what-if/ex-post scenarios have been identified, including the dry spells of 2003, 2005, 2007, 2011 (up to winter), 2012, 2017, and 2022.

The initial scoping meeting in February 2022 outlined the needs of various sectors, as well as spatial (for instance, the entire catchment's final section) and temporal (e.g., sub-seasonal, seasonal, annual, decadal, or climate change) scales of interest. This meeting was the starting point for co-generation and adaptation strategies. The first stakeholder workshop held in July 2022 focused on drought management, existing strategy limitations, the threats posed by climate change, and the data and tools that could be used to characterize the situation and formulate adaptation scenarios.

The subsequent workshop in March 2023 highlighted the need for more detailed information on expected changes in water availability, such as frequency and duration of extremes (well-represented in the projected FDCs), and compared this to specific thresholds (e.g., seasonal ecological flow values from regional regulations), incorporating the associated uncertainties.

For various users, water availability is a vital variable to preserve the water balance at the catchment closure, where most stakeholders (the "primary users" of water) have some withdrawals to serve their respective downstream users (for instance, farmers for irrigation or ceramic industries for multi-utility use).

In terms of the necessary information to address this challenge, stakeholders have helped identify a core set of data required to establish a water balance analysis. This ranges from meteorological maps to geographic data like terrain models and soil usage, through to existing climate projections. While most of this data can be sourced directly from public repositories, there is still a lack of local knowledge which must be filled with the aid of stakeholders. For instance, reliable withdrawal data is still missing according to all stakeholders involved.

Stakeholders are being called upon to help address this critical data gap, and feedback will be collected over the coming months. This active participation is also strategic, given the existence of conflicts over water resources during periods of scarcity, particularly in summer due to the concurrent presence of low resources and high demand for agriculture.

It became clear after the second workshop that the current baseline information source is the hydrological monitoring network of ARPAE, which does not include climate change projections specific to the area of interest. The current data sets, mostly meteorological, are used by some stakeholders to drive climate change projections of water demand, but not water availability. There is thus potential to contribute climate change scenarios of water availability to the discussion and formulation of adaptation strategies within the Lab.

Interestingly, during the second workshop, a broader perspective was introduced to the stakeholders, showcasing water availability/demand status and projections at the national/district level, and how economic models can be downscaled to assess the expected impact of drought. This area garnered interest given the difficulty in fully evaluating the interconnected economic damages of drought downstream the entire value chain.

While the co-generated strategies are necessarily focused on the Lab's specific geographical area, we will also consider the replicability of the Talanoa Dialogue outcomes to a broader context, to facilitate the exploitation and dissemination of results towards other users.

2.3.3. Strategy and Action Plan

The Talanoa Dialogue fosters co-generation based on interaction and engagement with a diverse group of stakeholders involved in water resource allocation, including both collaborators and competitors. This dialogue brings together researchers, policymakers, industry representatives, and other economically significant sectors.

The dialogues start from a solid common ground as most users are well-versed in the topic of water management in the context of climate change. They share a common understanding of the challenges and potential impacts of climate change on water resource availability. Furthermore, stakeholders have demonstrated a positive attitude towards innovation, particularly in relation to the Regional Government, ARPAE, and the Consortia, all of whom have prior experience participating in H2020 funded projects that develop and test innovative climate services in the water sector. This is exemplified by the Climate Service for irrigation forecasting developed by ARPAE for the Burana Consortium (Figure 12) [2].

[2] https://servizigis.arpae.it/moses/home/index.html

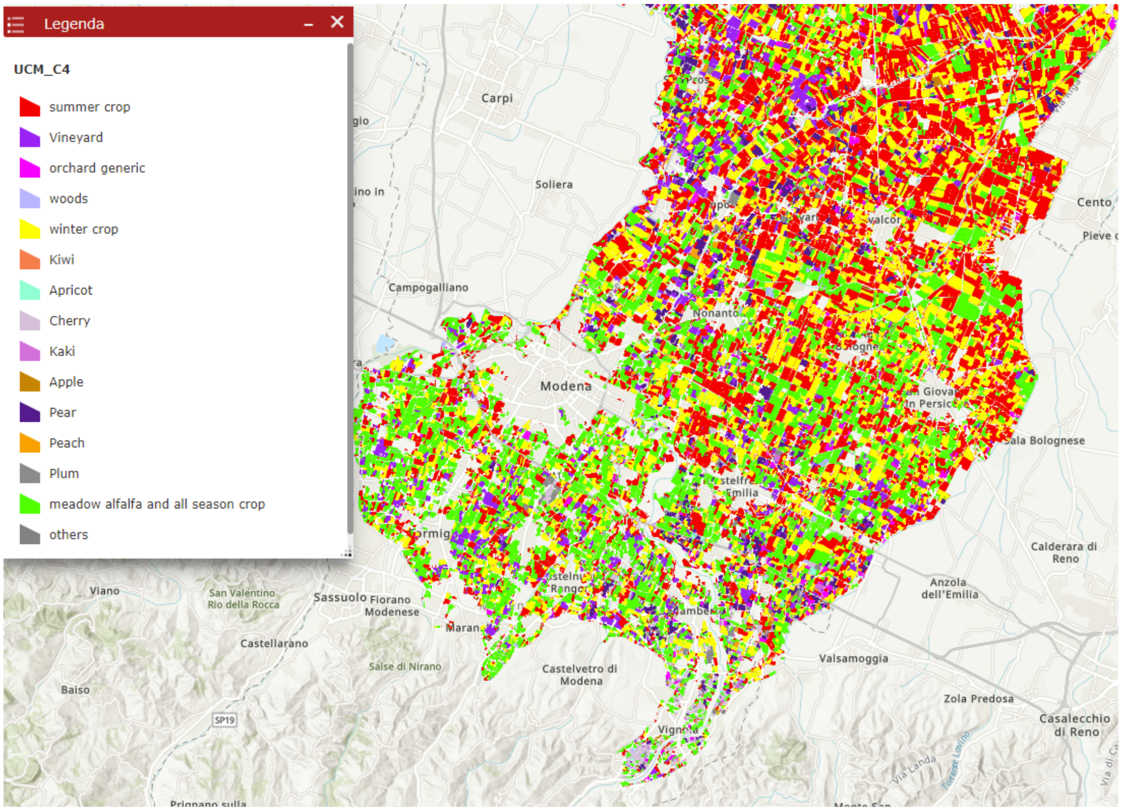


Figure 12. example of existing local climate service from ARPAE for Burana consortium (1)

Basic terminology and concepts, including climate projections and the required data for water availability assessment, are well-understood by all parties involved and do not hinder our interaction.

All participating organizations have interrelated roles in the water sector, particularly regarding climate change adaptation. The Regional Government sets the "rules of the game" through master plans for water management, thereby establishing limitations on water usage (for instance, defining the ecological flow to be maintained in rivers) and prioritizing usage.

Moreover, the Regional Government holds a clear mandate to update the water balance for Apennine rivers, including the one analyzed in this lab. It aims to address the challenges posed by climate change and the growing competition for water resources.

ARPAE plays a significant role as it issues withdrawal permits and manages the monitoring network. The data from this network serve as the primary reference for any action concerning water exploitation limits, especially seasonal withdrawal stops during droughts. As providers of climate services, ARPAE often operates more closely with some users, acting as consultants in the water sector for resource assessment and specific value-added information provision (as exemplified by the case of the Burana consortium).

Finally, users primarily interested in water provision (such as multi-utilities, hydropower producers, and consortiums), while less active on the policy side, can play a major role in adaptation. They can do this by acting towards the final user they provide water to or by exploring alternative water resources.

When it comes to adaptation strategies, stakeholders have provided numerous examples:

- The Regional Government emphasized the need to update master plans and withdrawal regulations, considering the effects of climate change on water availability and temporal distribution. This update is crucial to ensure water resources for legitimate users, including economically significant sectors like hydropower, agriculture, and industry, while preserving (and possibly improving) the environmental and ecological status of the river.
- Further downstream users, such as hydropower and multi-utility companies, have highlighted the value of project Flow Duration Curves (FDCs) for the financial sustainability of existing and new projects. These curves provide insights into the availability and variability of water resources, enabling better planning and decision-making.
- The irrigation consortia have emphasized the strategic use of projections and economic evaluations to prioritize water allocation among competing users. They also aim to implement long-term infrastructure measures, such as storage volumes and distribution network updates, to ensure efficient water management.

The upcoming focus in the lab will be on integrating local models, temporal scenarios of interest, and adaptation strategies into a co-developed multi-system modeling framework. This collaborative effort will enable a comprehensive understanding of the complex interactions between various factors and facilitate the development of effective adaptation measures.

In decision-making processes related to small rivers, coordination and shared countermeasures for drought emergencies often present challenges. These processes tend to prioritize long-term planning and policy-making over immediate operational management. However, the increasing frequency of water shortages necessitates effective management of conflicts arising from competing water usage, even in the short term.

It is important to note that, in addition to their obvious public functions, final users (such as multi-utility and consortium companies) are legally recognized as providers of essential services to the public. Consequently, they adhere to specific ethical rules when interacting with third parties, including R&D partners. Despite operating in the market and understanding the needs of for-profit entities, they are committed to fulfilling their public interest responsibilities.

These elements create a favorable environment for agreeing on core values during lab activities and co-designing adaptation strategies through the Talanoa Dialogue.

During the second Talanoa workshop, particular attention was given to the decision-making process, with a specific focus on the Regional Government. They outlined a set of possible actions supported by updated water availability projections, including:

- Updating rules for withdrawal permits and developing new strategies for efficient water storage and demand reallocation under climate change conditions. These measures aim to enhance the resilience of the system by both storing and reducing water demand.

- Updating environmental flow requirements and related exceptions to ensure the resilience of the water system in the face of changing conditions.

- Identifying win-win storage solutions that are cost-effective and appropriately located to benefit multiple stakeholders.

- Isolating a worst-case period of 10-20 years in the future to compare projected Flow Duration Curves with actual observed values. This evaluation will help assess the effectiveness of adaptation strategies under different scenarios.

Hereafter we summarize **Key Messages of the 1st Workshop Targeted to WPs** (and specific tasks)

WP1 – ENGAGE

T1.2 – The approach of reducing organizers' frontal presentations and allowing more time for guided discussion among stakeholders has proven successful. Compared to the first workshop, there was a significant improvement in distributing time equally among stakeholders, as they were asked to prepare short contributions of 10 minutes each to kickstart the discussions.

Post-workshop surveys were sent via email as a follow-up, and so far, we have received a good response rate, with the majority of participants expressing satisfaction with the workshop format.

WP3 – MODELING

T3.2 – The workshop highlighted the importance of integrating regulations at the local, regional, and district levels. For the multi-model framework to effectively support local management and decision-making, it must be reliable and tailored to the specific territory. Forecasting scenarios can play a key role in initiating dialogue between the managing entity and users, as well as in mitigating conflicts among different stakeholders.

There is a strong interest in seasonal to climatic projections, not only in terms of general trends and monthly statistics, but also in understanding changes in the frequency and duration of different daily flow regimes and drought seasons.

Multiple stakeholders have raised concerns about the uncertainty associated with the provided forecasts. Clear articulation of the economic damages caused by resource scarcity or inaccurate forecasts remains a challenge in different sectors. This is linked to the previous workshop outcome, which identified collateral and cascade effects of climate change on complex economic systems (e.g., increased temperatures leading to energy system failures or environmental quality threats).

Considering the focus of WP3, it is crucial to develop the multi-model framework to assess the effects of climate change scenarios on multiple sectors. The framework should enable the simulation of direct and indirect impacts, thereby providing a support system for stakeholder discussions on mitigation measures.

WP4 – LABORATORIES

T4.1 – Stakeholders have expressed their interest in a service that can model hydrological as well as socio-economic scenarios, considering the multiple effects of adaptation strategies on the environment and various socio-economic sectors. Historical drought periods such as 2003, 2005, 2007, 2011 (up to winter), 2012, 2017, and 2022 have been identified as potential scenarios for analysis and simulations.

This aligns with the previous workshop outcomes, where stakeholders provided indications on scenarios of interest, specifically focusing on extreme drought and its impact on water availability (e.g., hydrological regimes such as Flow Duration Curves) and relevant sectors. They also discussed possible adaptation strategies, including consumption reduction, financial compensations, changes in regulations for hydropower, and investments in infrastructure to reduce water leakages.

T4.2 – Stakeholders in the laboratory, particularly ARPAE and the Consortia, possess specific knowledge and expertise in hydrological modeling and data. Integrating their models, local knowledge, and data with the output of WP3 models can be a promising approach to further involve them and generate continued interest.

WP5 – EXPLOIT

5.2 – The availability of stakeholders' communication channels for targeted dissemination of project advancements has been confirmed, starting with the Emilia Romagna Region and the Burana Consortium. It is recommended to propose a press release or dedicated news to stakeholders for dissemination through their official channels, ensuring effective communication and outreach.

2.4. Lebanon

2.4.1. Current Status

A) A glimpse of the Lebanese Lab –The Litani River Basin (LRB)

The Litani River (Leontes) is the longest river in Lebanon, and its watershed area is one-fifth of the country's area. The Litani River Basin comprises two primary hydrologic units: the Upper Litani Basin and the Lower Litani Basin. These two units are connected in the central part of the basin at the Qaraoun reservoir. The area of interest lies within the Upper Litani River Basin, where the Bekaa agricultural plain is situated. The river rises from the Allaik Spring at an altitude of 1000 m west of the city of Baalbek. It flows 176 Km and is fed by other larger springs before it is dammed by the Albert-BNaqqash Dam forming the Qaraoun reservoir (228 mcm). It continues its path before it turns sharply westwards and empties into the Mediterranean Sea 9 Km north of the ancient city of Tyre in South Lebanon (Figure 13). The Litani river basin is rich in agricultural land and is a source of income for over 1 million inhabitants, who usually use it for irrigation, industrial, and summer recreational activities. The Litani River Basin (LRB) spans across different topographical and cadastral regions. LRB joins the inner and the coastal zones of Lebanon, located between the following geographic coordinates: 33° 06′ 25″N and 34° 04′ 05″N and 35° 14′ 40″E and 36° 22′ 44″E.

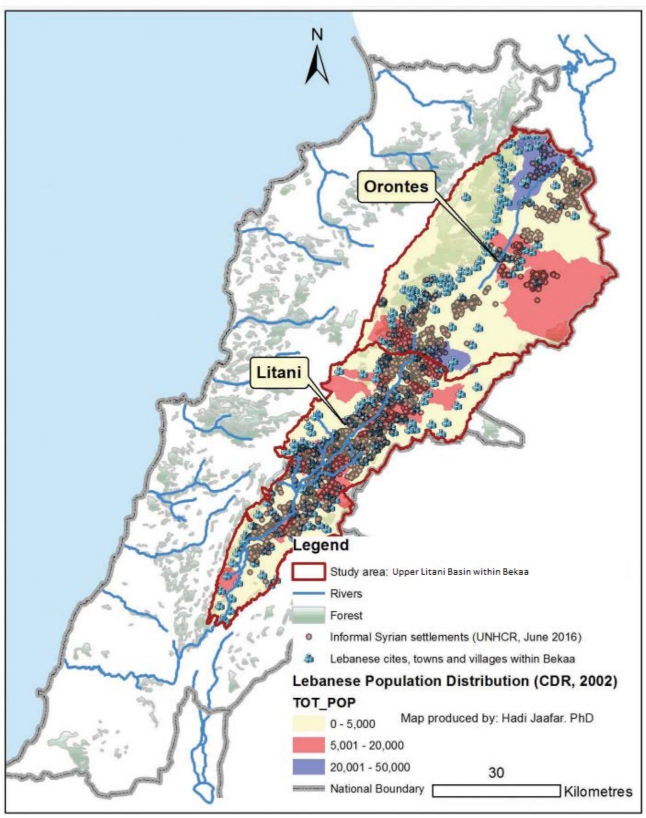
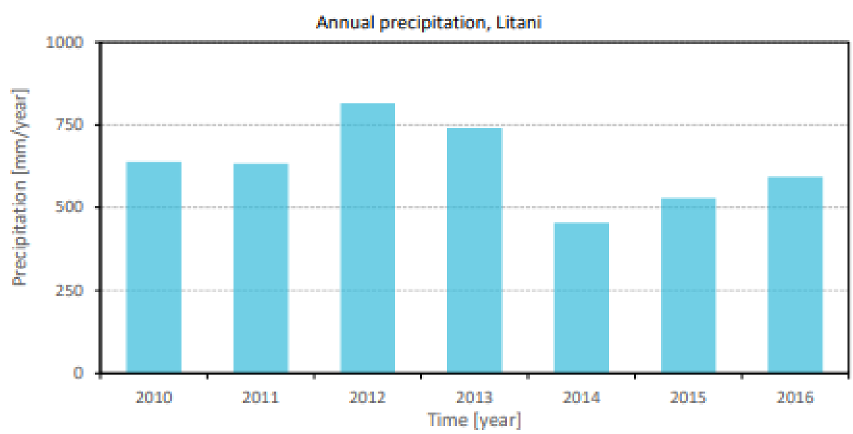


Figure 13. Location of the Upper Litani River Basin on the map of Lebanon (Jaafar et al., 2016).

B) Climate

The river crosses through three microclimatic regions: the semi-arid flood plain in the Bekaa Plain upstream of the Qaraoun Reservoir, the temperate wet Mediterranean area in the mountainous region between the two Qaraoun and the coastal plain, and the hot, humid coastal plain (LRA & Association, 2007). Due to its diverse topography, the temperature is characterized by an abrupt difference in the catchment of LRB. The mean monthly temperature is about 21.5 °C (CNRS-L, 2015). The average maximum temperature ranges from 15 to 28 °C, and the average minimum is about 12 °C. The basin is the largest catchment in the country (2,176 km^2), draining 20% of the total area of Lebanon. The Litani River Basin (LRB) is replenished annually by local precipitation events, restricted to around 90 to 100 days between October and April and snowmelt. The average annual precipitation over the river basin area (2168 Km^2) is 630 mm/year – 1370 Mm^3/year. As a result, the river flow tends to be seasonal with significant inter-annual variability. Currently, the river flow monitoring is implemented by the Litani River Authority (LRA), which operates two fixed gauging stations located in the upper Litani (Joub Janine) and lower Litani (before discharge). Moreover, snowfall occurs in regions above 1200 m, occurring about 25–30 days per year (Figure 14).



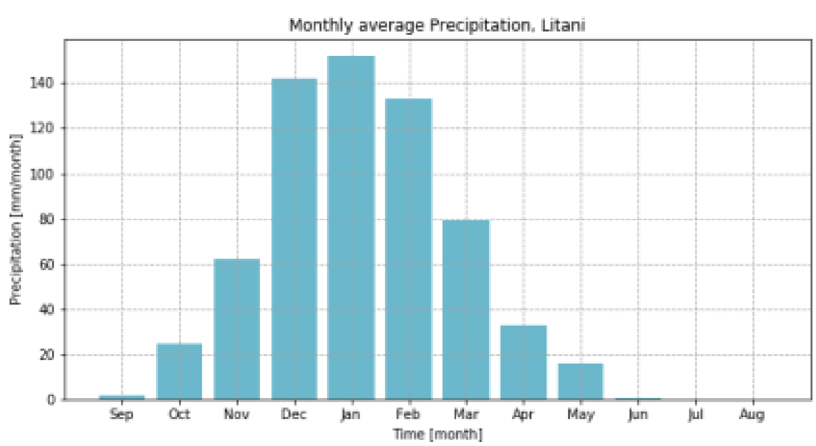


Figure 14. Annual (upper) and monthly average (lower) precipitation in the Litani basin for a period of 9 years (2009 to 2017) (IHE 2019, water accounting in the Litani River Basin technical report)

C) LRB Water resources—Current Situation:

i) Water Storage

The Qaraoun reservoir is one of the largest dams on the Litani River, constructed in the period 1958-1965 in the South Bekaa area close to the eastern foothills of Niha Mountain. The static storage capacity of the Dam is estimated at around 220 MCM. Therefore, the LRB has a high potential for irrigation and energy production. Currently, only 30 MCM are being utilized from the Qaraoun Dam for water supply and irrigation projects, and the rest is used to generate hydropower (MoEW, 2019).

ii) Rising population

Population growth is the main driving force modulating the demands on the available water resources across the LRB, where more than 800,000 people live under high water stress (Jaafar, Ahmad, Holtmeier, & King-Okumu, 2020). Population growth rates in Lebanon range between 1 and 2.5% per year. According to the 2020 National Water Sector Strategy (NWSS) by the Ministry of Energy and Water (MoEW), it is expected that population growth will be 1.5% for rural areas, like that of LRB, and 0.75% for urban areas between 2020 and 2035 (MoEW, 2019). The Syrian crisis has exacerbated the situation, which caused a massive influx of displaced people into Lebanon. Currently, refugees and displaced represent around 30% of the Lebanese population, constituting the world's highest number of refugees and displaced per inhabitant. It is estimated that the refugees' influx increased the national water demand by 8 to 12% and the wastewater generation rate by 8 to 14% (MoE, EU, & UNDP, 2016). Expanding population squeezes the basin's capacity, resulting in growing water demands, leaving water availability of only 800 cubic meters per capita per year.

iii) Groundwater resources depletion

Presently, groundwater resources in the basin are depleted by around 57.5 million cubic meters per year, and water storage decreases to about 50 million cubic meters per year (IHE, 2019).A study performed by United States Agency for International Development (USAID) for groundwater depth monitoring in eight wells throughout the Bekaa Valley shows a significant drop in most wells between 2012 and 2016, some more severe than others. The increase in depth to groundwater could be attributed to over-exploitation due to escalating urbanization and a reduction in groundwater recharge due to a decrease in snow cover (Shaban, 2009). Figures 15 and 16 show the depth to groundwater at two selected well sites.

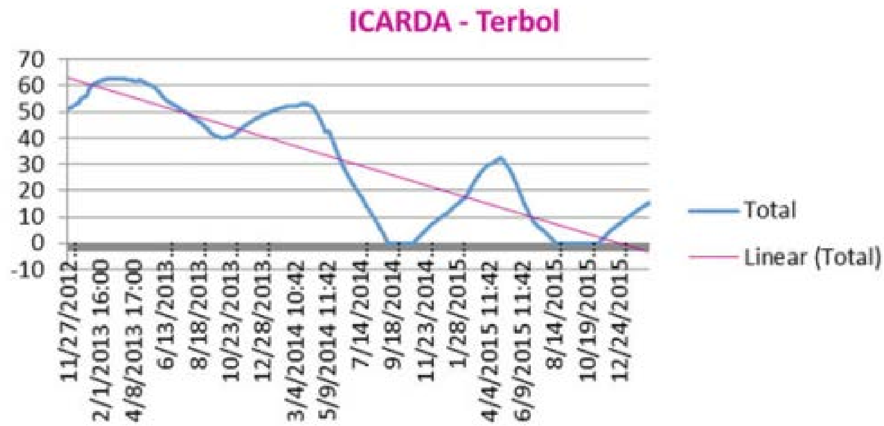


Figure 15. Depth to groundwater at ICARDA's Terbol site (Shaban & Hamzé, 2018)

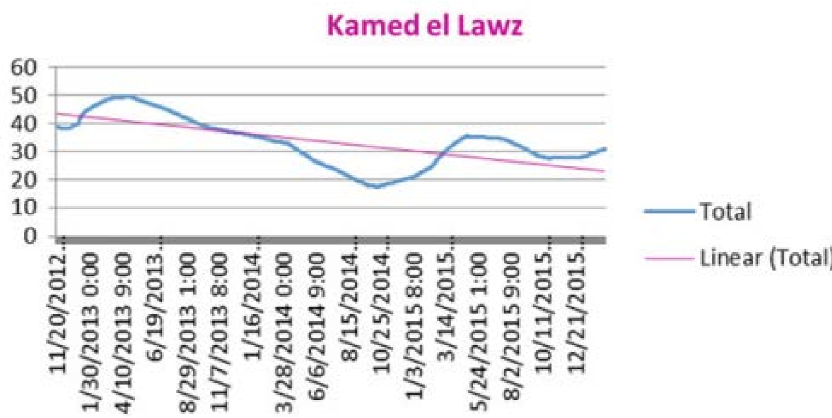


Figure 16. Depth to groundwater at Kamed el Lawz (Shaban & Hamzé, 2018)

iv) Climate change

In Lebanon, projected climate change is expected to impact its water resources and increase water shortages negatively. The lack of long-term time series associated with the inter-annual variability and the inability to separate the physical from the anthropogenic disturbances make it difficult and uncertain to quantify the climatic trends in the Lebanese hydrological system (Telesca et al., 2014). Previous research shows that the snow cover, precipitation, and average discharge rates of Lebanese rivers dropped by 12%, 16%, and 23%, respectively, between 1965 and 2005. Moderate and worst-case scenarios predict temperature rise by 1.2°C to 1.7°C and up to 3.2°C by 2100, compared to the baseline period of 1986-2005. Precipitation is projected to drop by 4 to 11% under both scenarios, respectively. Snow cover is expected to decrease by 70%, and snow residence time is estimated to reduce from 110 days to 45 days (MoE, EU, & UNDP, 2016).

D) Significance of the Litani River

The Litani River has always been well-thought-out as a primary component in the socio-economic development of Lebanon. First, the Litani River irrigates extensive agricultural lands. It contributes to the irrigation of thousands of hectares of farmland and to the water needs of over a million inhabitants. It secures wetlands, a major reservoir, and the watershed ecosystem. Around 31% of the income within the basin comes from agriculture, where 6% of the inhabitants of the basin depend on agriculture as a major source of income (IDRC, CNRS-L, LRA, & DSA, 2007). Second, the river is a major source of energy for electricity generation. The water flows into three electricity plants: The Qaraoun, Markaba, and Al-Awali stations. The Qaraoun has been in operation for hydropower since its construction. The three plants generate electrical energy averaging about 190 megawatts, equivalent to 10–12% of Lebanon's electricity needs.

E) Stakeholders' involvement

At first, we assembled a group of stakeholders who are most involved in managing water resources in the Litani River Basin (Table 9). This group was convened to discuss important scientific themes and to address the challenges that were mentioned earlier. After the successful completion of the first national stakeholder workshop and attendance at the serious game training workshop conducted by Lisode in Montpellier, France, in December 2022, we mapped out the stakeholders and used this information to refine the group of stakeholders who participated in the second national workshop (Figure 17).

Original Identified Stakeholders	Litani River Authority (LRA)
	Bekaa Water Establishment
	South Lebanon Water Establishment
	Beirut & Mount Lebanon Water Establishment
	Ministry of Agriculture
	Ministry of Water and Energy
	Ministry of Environment
	Lebanese Agricultural Research Institute (LARI)
	ICARDA

	Farmers
	Water Users (households, industries, restaurants)
	Food and Agriculture Organization (FAO)
Stakeholders Participating in the 1st Lebanese National Workshop	Litani River Authority (LRA)
	Bekaa Water Establishment
	South Lebanon Water Establishment
	Ministry of Agriculture
	Lebanese Agricultural Research Institute (LARI)
	ICARDA
	Food and Agriculture Organization (FAO)
	American University of Beirut (AUB)
	UNESCWA
	World Food Program (WFP)
Stakeholders Participating in the 2nd Lebanese National Workshop	Bekaa Water Establishment
	South Lebanon Water Establishment
	Beirut & Mount Lebanon Water Establishment
	North Lebanon Water Establishment
	Lebanese University
	Lebanese Agricultural Research Institute (LARI)

	American University of Beirut (AUB)
	Farmer
	Litani River Authority (LRA)

Table 9. Lists of originally identified local stakeholders and stakeholders who participated in the first and second Lebanese National workshop.

One feedback from the stakeholders during the first workshop regarding the engagement process is to focus on attainable objectives and gain acceptance from key stakeholders, and to allow stakeholders to take ownership of measurable objectives to feel accountable for them and maintain interest in identifying effective strategies. As a way to achieve this suggestion, we conducted an extensive stakeholder mapping exercise in Montpellier (Figure 17). We identified potential contributors to the upcoming workshops and serious game and mapped them according to their level of interest in the Litani watershed management and their power levels. Additionally, we identified the various processes impacting the basin, including state failure, demographic explosion, economic shocks, and the decrease in summer flows. We also gained an understanding of the impact and interdependencies between different water uses on the water balance in the basin. Given the complex nature of the relationships between all water users, we simplified the situation to present a comprehensible version of reality and identified the resources used by each of the identified stakeholders. The stakeholder mapping served as an initial step in identifying and selecting the most relevant stakeholders who will take part in the second national workshop.

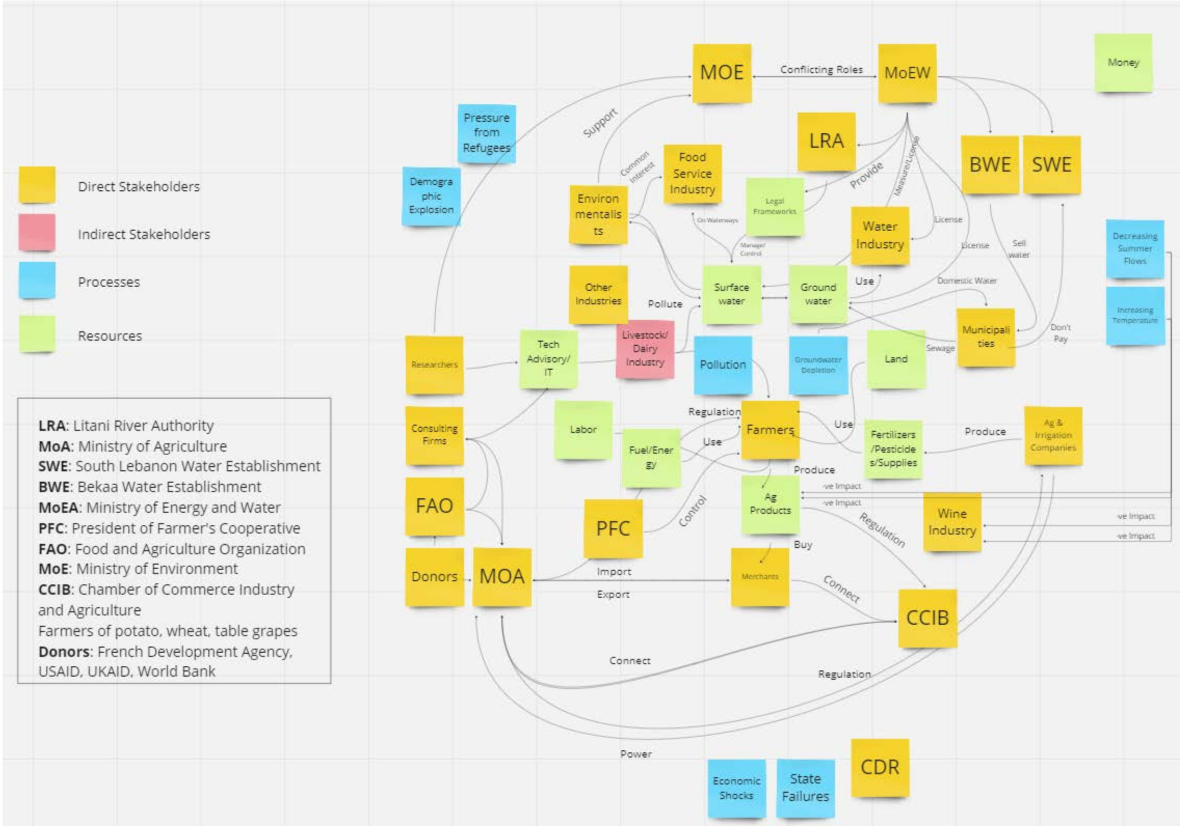


Figure 17. Extensive stakeholder mapping of the Litani River Basin.

2.4.2. Vision and Objectives

Our efforts to manage the water resources of the Litani River Basin were significantly bolstered following the successful completion of the first national stakeholder workshop on July 13, 2022 (Figure 18). The workshop was highly interactive and featured the participation of 11 influential stakeholders and policymakers, each holding senior positions in the public and private sectors, as well as international organizations. The stakeholders were representatives of the Litani River Authority (LRA), Ministry of Agriculture, Lebanese Agricultural Research Institute (LARI), Bekaa Water Establishment, South Lebanon Water Establishment, International Center for Agricultural Research in the Dry Areas (ICARDA), FAO, WFP, UNESCWA, and the American University of Beirut (AUB). We fostered an open and inclusive consensus-building and decision-making approach through five rounds of stakeholder discussions. The workshop incorporated formal and informal discussions, with direct feedback from the stakeholders by sharing local knowledge and identifying gaps between research and field expertise. Opportunities of collaborations between stakeholders also arose during the workshop.

The modeling framework, which integrated remotely sensed biomass and evapotranspiration data with socioeconomic data via a multi-model ensemble of Mathematical Programming Models, generated significant interest from stakeholders, despite some concerns about modeling uncertainties. Stakeholders highlighted that water pricing could be a valuable tool for improving water management policies. However, they also recognized that it may present a social challenge to Lebanese farmers who have traditionally used surface irrigation methods that require substantial amounts of water. This first workshop consisted of a series of presentations by the organizers briefing the attendants about the project, the role of stakeholders in shaping water and agricultural policies, preliminary results of Water Accounting Plus (WA+) and of remote sensing and socio-economic simulations. The workshop also included a welcoming note and presentation by the project rapporteur Mr. Nassim Abou Hamad, representative of the Litani River Authority. During the discussion, concerns were raised about the rising costs of fuel and the strategies that emerging farmers are using to adapt. For example, some farmers are turning to solar energy as a more affordable and sustainable option for pumping groundwater for irrigation.

Figure 18. Images of the first Lebanese national science-policy stakeholder workshop.

For the second national stakeholder workshop, we planned to improve upon the discussions that were held during the first workshop by incorporating the measures raised by stakeholders into a serious game format (Figure 19). Our approach involved a range of tools, including live polls, workshop surveys to identify problems and potential strategies, and pre- and post-workshop surveys. The introduction of these dynamic tools for this year's event made it more engaging compared to the previous workshop, where such tools were not yet implemented. We also expanded our channels of interaction with stakeholders by increasing the number of bilateral meetings, email exchanges, direct phone calls, and invitation letters. As a result, the representation of organizations in terms of gender balance has improved compared to the first workshop. The workshop also emphasized receiving feedback from stakeholders collected towards work packages, and on how to further enhance the serious game and encourage active engagement in dialogues, particularly with ministries. Additionally, the second workshop introduced ideas for a second serious game that would be implemented in the third national stakeholder workshop. The process of involving stakeholders was flexible, and they were given the opportunity to modify their strategies every decade (2025, 2035, and 2045) and suggest alternative adaptation policies. Through the interaction with stakeholders, a hierarchy of proposed adaptation strategies was established, and novel adaptation policies were identified for testing in upcoming modeling rounds. The pre-built scenarios were improved and rectified by incorporating several cycles of input on their realism, consistency, and impact on agriculture and water management in the basin.

Figure 19. Images of the second Lebanese national science-policy stakeholder workshop.

The proposed measures were jointly evaluated with stakeholders based on the respective environmental, economic, and social impacts, and the estimated cost of implementing each strategy was considered. During the strategy selection surveys, participants initially tended to favor measures with an economic focus in the first round. However, there was a shift towards selecting environmental strategies in the subsequent two rounds. Stakeholders expressed the need for the engagement of ministry representatives in similar workshops. Most participants agreed that it was better to view the impacts of the measures in a comparative manner rather than assessing them individually. In the problem identification poll, heavy pollution from untreated waste in the basin was ranked as the most pressing issue in the first round. The second-ranked concern was the demographic explosion, while the decrease in summer flows was ranked third. In the poll aimed at prioritizing actions to improve the situation, wastewater treatment was ranked as the top priority by respondents, followed by water pricing in second place, and technological innovation for water saving in third place. Stakeholders reached a consensus on the crucial role of remote sensing technologies and the significance of leveraging such technologies to inform evidence-based decision-making, especially open-access data sources, in addressing the data scarcity challenge faced by countries like Lebanon. During the stakeholder consultations, it was observed that some strategies which are effective in one zone of the Upper Litani Basin may not necessarily be applicable to other zones within the same basin. Rather, a more nuanced approach may be required, where strategies are tailored to the specific needs and characteristics of each zone in order to maximize their effectiveness. Participants also expressed that stakeholders are often guided by their bylaws and the regulations of their respective organizations.

2.4.3. Strategy and Action Plan

The Litani River Authority (LRA) was represented in the first and second workshops, and we strive to maintain their participation in all subsequent workshops. We have also devised a plan to involve representatives from the LRA in international conferences, such as the upcoming EAERE 2023 conference in Limassol, Cyprus, in June 2023. Dr. Francesco Sapino (USAL), Ms. Rim Hazimeh (AUB), and Ms. Juliette Le Gallo (INRAE) prepared a policy session proposal "Water Dialogues for Sustainability", which has already been approved for presentation at the conference. This will provide an excellent opportunity for LRA representatives to engage with experts in the field and share their experiences and insights on managing water resources in the Litani River Basin, and on the challenges and opportunities for policy implementation in the basin. The LRA is a crucial stakeholder with significant interest and influence in the Litani-related project. As a regulatory body, the LRA is empowered to take legal action related to the water management process, by implementing and overseeing projects and ensuring the maintenance and exploitation of water facilities.

Currently, some stakeholders possess limited knowledge of the quantitative issues faced by the basin, with a greater emphasis placed on the issue of water quality. We plan to disseminate the results of Water Accounting Plus to provide stakeholders with a comprehensive understanding of the basin's inflows and outflows, and to better equip stakeholders to understand the quantitative aspects of the issue and its potential impact on the management of the watershed. Based on the stakeholder dialogues, we plan to incorporate an additional aspect into the survey - the motivation of stakeholders. Stakeholders expressed that it is important to recognize that the motivations of a researcher and stakeholders differ. While the primary goal of any policy is to meet the demand, stakeholders tend to prioritize factors such as operational and maintenance costs.

Despite inviting all relevant ministries to the first and second workshops, only the Ministry of Agriculture was represented in the first workshop. However, in the upcoming workshops, we plan to expand the scope of participating ministries to include the Ministry of Environment and the Ministry of Energy and Water. These ministries are essential stakeholders with the power and capacity to act as intermediaries between various stakeholders involved in the water sector, including water users, local and regional decision-makers, and international organizations. They can also stimulate public and private investments in the agricultural and water sectors by mobilizing the necessary national and external resources for priority public investments and supporting coordination among various actors in the basin. Additionally, the upcoming third workshop will implement the renewed card-based serious game (developed by the USAL team).

Hereafter we summarize **Key Messages of the 1st Workshop Targeted to WPs** (and specific tasks)

WP1 – ENGAGE

1.2. In upcoming workshops, it is planned to prioritize the involvement of farmers and representatives from the ministries, as they were either under-represented or absent in the previous workshop. A gender-balanced representation of organizations should also be maintained in upcoming dialogues.

To improve the serious game, it is suggested that the motivation of stakeholders be included in its initial stages. In the second workshop, participants stressed the importance of acknowledging the difference in motivation between a researcher and a stakeholder.

WP2 – DATA

2.1. Continue leveraging on remote sensing technologies in the design of adaptation strategies and in the refinement of the modeling framework to inform evidence-based decision-making. This should include the use of open-access databases, which can facilitate sharing and integration of data across different stakeholders and sectors.

WP3 – MODELING

3.1. To enhance modeling efforts, it is recommended to engage in in-depth discussions with stakeholders regarding the feasibility and limitations of the projected simulations. This will help to identify areas that require improvement and ensure that the modeling accurately reflects the needs and priorities of stakeholders.

3.2. The scenario building exercise, which was based on the strategy selection surveys, proved useful in identifying the stakeholders' inclination towards preferred measures. However, in future workshops, it is advisable to evaluate the impact of these measures in a comparative manner rather than assessing them individually.

WP4 – LABORATORIES

4.2. The stakeholders were involved in a joint evaluation of the proposed measures, taking into consideration their environmental, economic, and social impacts, as well as the estimated implementation costs. To promote empathy and encourage diverse perspectives in the dialogue, the upcoming workshop will feature a renewed card-based serious game developed by USAL.

Subject to feasibility, a targeted meeting could be arranged with farmers from various districts within the Litani River Basin to hear their experiences and gather their opinions on the different strategies identified.

WP5 – EXPLOIT

5.2. The progress of the project will be shared and utilized across various international conferences, including the EAERE 2023 conference. Stakeholder efforts are underway to further disseminate information and facilitate action within their respective organizations. The water laboratory's project activity news is disseminated during and after the workshop on the lab's Twitter, LinkedIn, and Blog profiles.

2.5. Tunisia

2.5.1. Current Status

The Tunisian water lab (Djeffara water lab) is in the governorate of Medenine, South-East Tunisia. It is a coastal plain bounded by the region of Gabes in the north (Oued Akarit represents the discharge of the Djeffara), the northeastern Libya in the south, the Mediterranean coast in the east and the Mountain chain of the Dahar plateau in the west. The selected area for this study comprises a subzone of the Djeffara called the Djeffara of Medenine. It contains the maritime Djeffara (peninsulas of Jorf and Zarzis), the island of Djerba and the plain of Ben Guerdane. The plain covers 16000 km 2 and stretches over 205 km in coast length. The location can be visualized on Figure 20. Due to its geographical location, the study area is characterized by an arid climate. The precipitation irregularities in space and time are mainly due to the influence of the Mediterranean Sea, on the one hand, and of hot dry air mass coming from the Sahara.

Figure 20. Location of the study area of Djeffara Lab.

The mean rainfall varies from 225 to less than 100 mm/year (Figure 21).

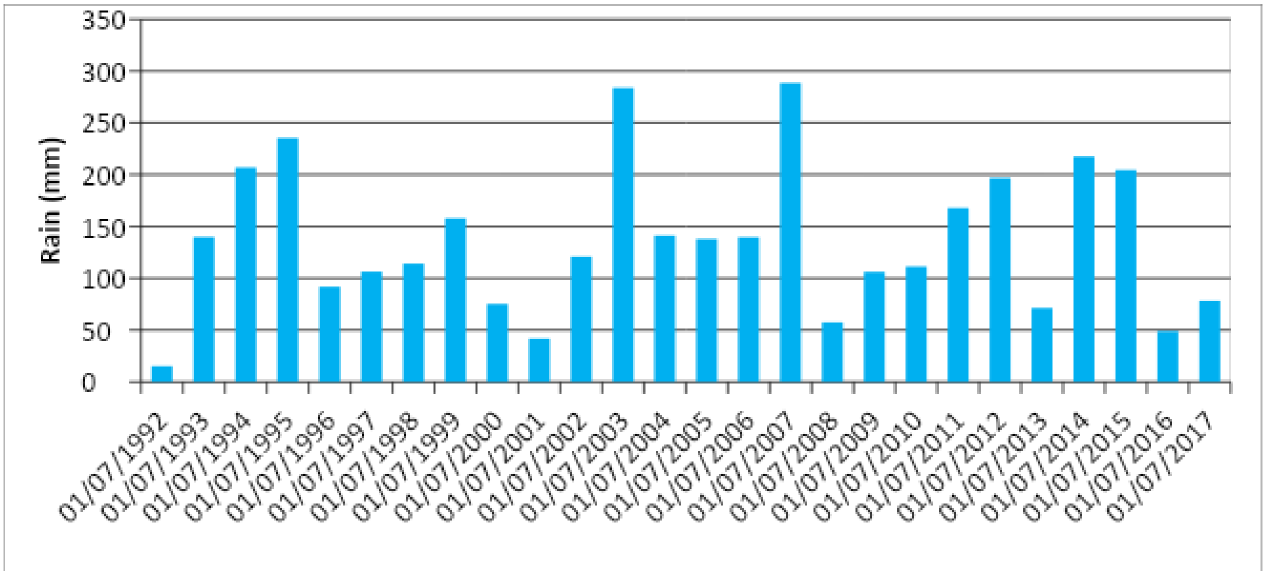


Figure 21. Rainfall trends 1992-2017.

The mean annual temperature is 20.6°C. The wettest months are September and October, and the driest are July and August (Figure 22).

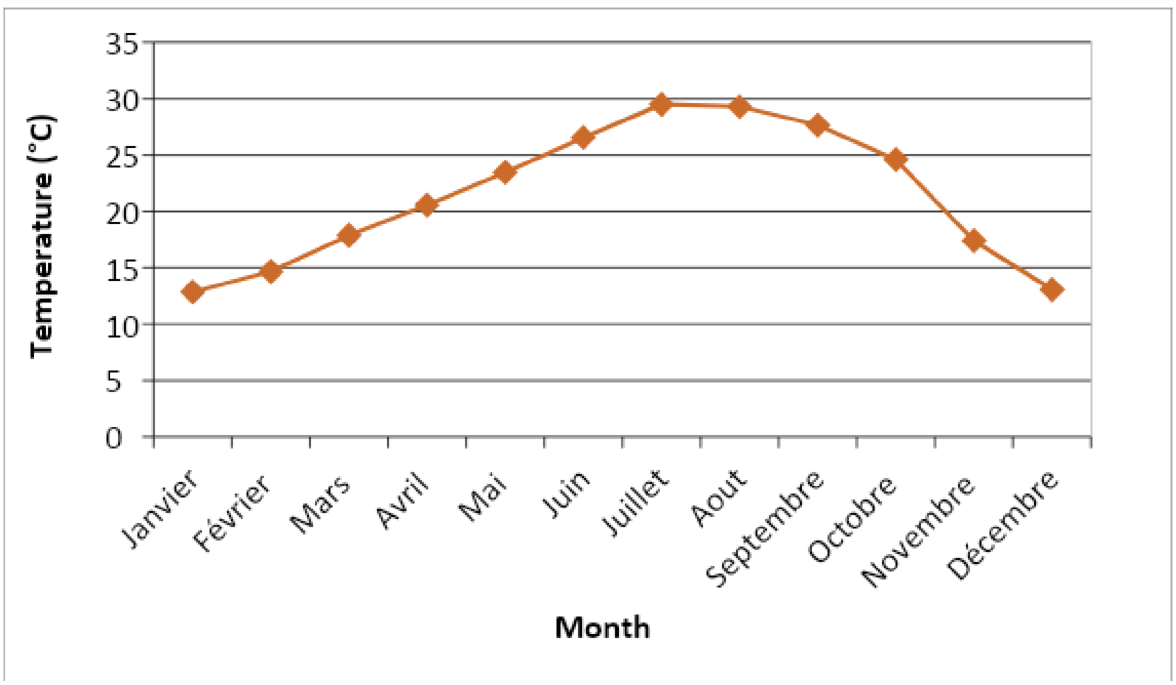


Figure 22. Monthly evolution of the temperature.

The Potential evapotranspiration rate exceeds 1,700 mm/year. The surface drainage has an intermittent flow regime because of long drought periods. The climatic water balance of the region is negative, mainly in the period of April – September, and it reflects the importance of climate impact on the water resources management (Figure 23).

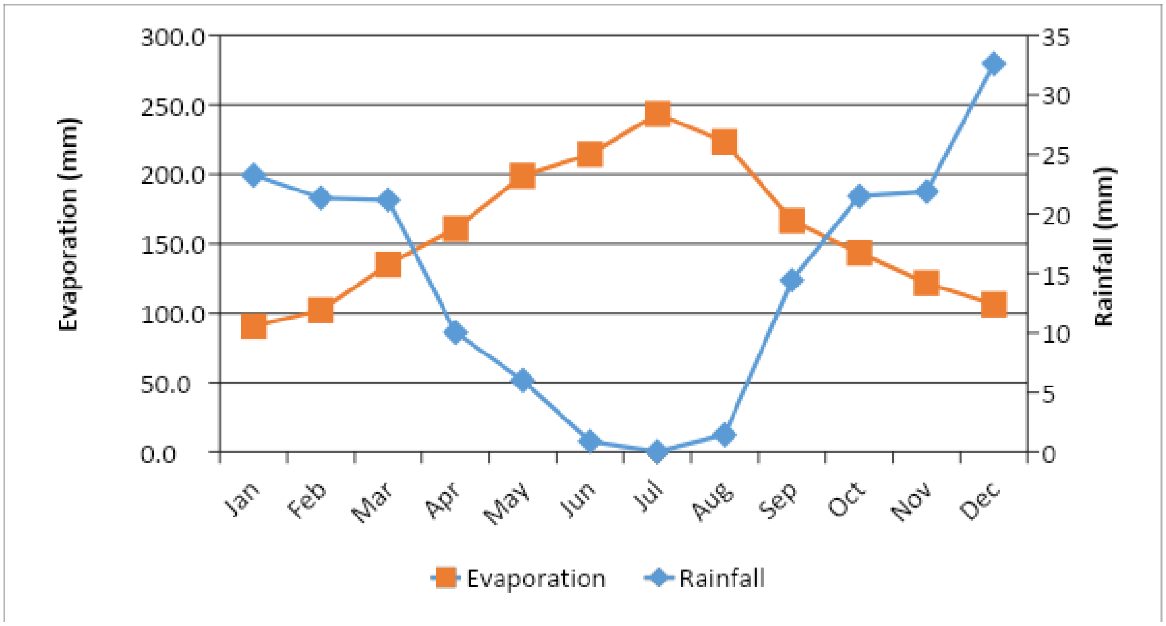
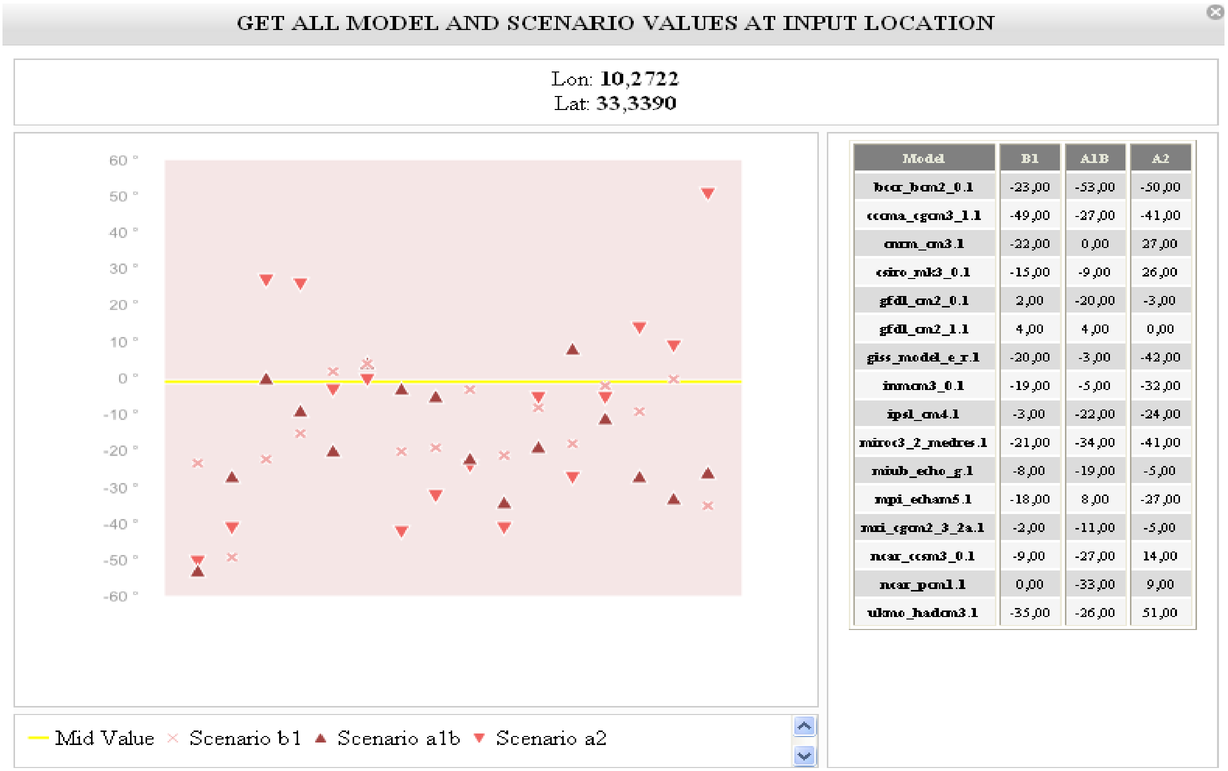


Figure 23. Monthly evolution of evaporation/Rainfall.

The region covered by the Djeffara Water Lab is expected to face strong climate change in the near future according to the IPCC. In order to explore potential changes, future climatic data were collected from the ClimateWizard website (The Nature Conservancy, University of Washington and University of Southern Mississippi). This website provides the calculation results of all available GCCMs with A2, B1 and A1B emission scenarios. It should be noted that the RCP4.5 and the SRES B1 scenarios are comparable. The RCP6.0 lies between the SRES B1 and A1B scenarios. While the RCP8.5 has comparable forcing to SRES A2 (IPCC 2014).

Figure 24 shows the percentage of change in precipitation for the month of December 2050. It also provides the calculation results of all available GCCMs with A2, B1 and A1B SRES-emission scenarios.



Model	B1	A1B	A2
bccr_bcm2_0.1	-23,00	-53,00	-50,00
cccma_cgcm3_1.1	-49,00	-27,00	-41,00
cnrm_cm3.1	-22,00	0,00	27,00
csiro_mk3_0.1	-15,00	-9,00	26,00
gfdl_cm2_0.1	2,00	-20,00	-3,00
gfdl_cm2_1.1	4,00	4,00	0,00
giss_model_e_r.1	-20,00	-3,00	-42,00
inmcm3_0.1	-19,00	-5,00	-32,00
ipsl_cm4.1	-3,00	-22,00	-24,00
miroc3_2_medres.1	-21,00	-34,00	-41,00
miub_echo_g.1	-8,00	-19,00	-5,00
mpi_echam5.1	-18,00	8,00	-27,00
mri_cgcm2_3_2a.1	-2,00	-11,00	-5,00
ncar_ccsm3_0.1	-9,00	-27,00	14,00
ncar_pcm1.1	0,00	-33,00	9,00
ukmo_hadcm3.1	-35,00	-26,00	51,00

Figure 24. Precipitation changes calculated by the GCCMs under B1, A1B and A2 SRES scenarios for January 2050 (ClimateWizard).

Figure 25 shows the precipitation changes for 2050. The pessimist scenario predicts a precipitation decrease for all months of the year, with an annual average decrease of about 58%. However, the optimistic one presents a mean annual precipitation increase of about 74% for the same year. Then, an average CC condition was deduced with a mean annual decrease of about 13% for 2050.

The evaporation changes were given from the study of the CC impact on the durum wheat cultivation in Tunisia (Lhomme et al. 2009). It gave the rate of changes in evaporation for the year 2050. These changes consist of an increase of the evapotranspiration between 8 and 15% during the months of the year 2050 (Figure 26). On the other hand, the CC projections estimated a reduction of 70% in the recharge rate by the 2050s in the southern Mediterranean coast (IPCC 2008).

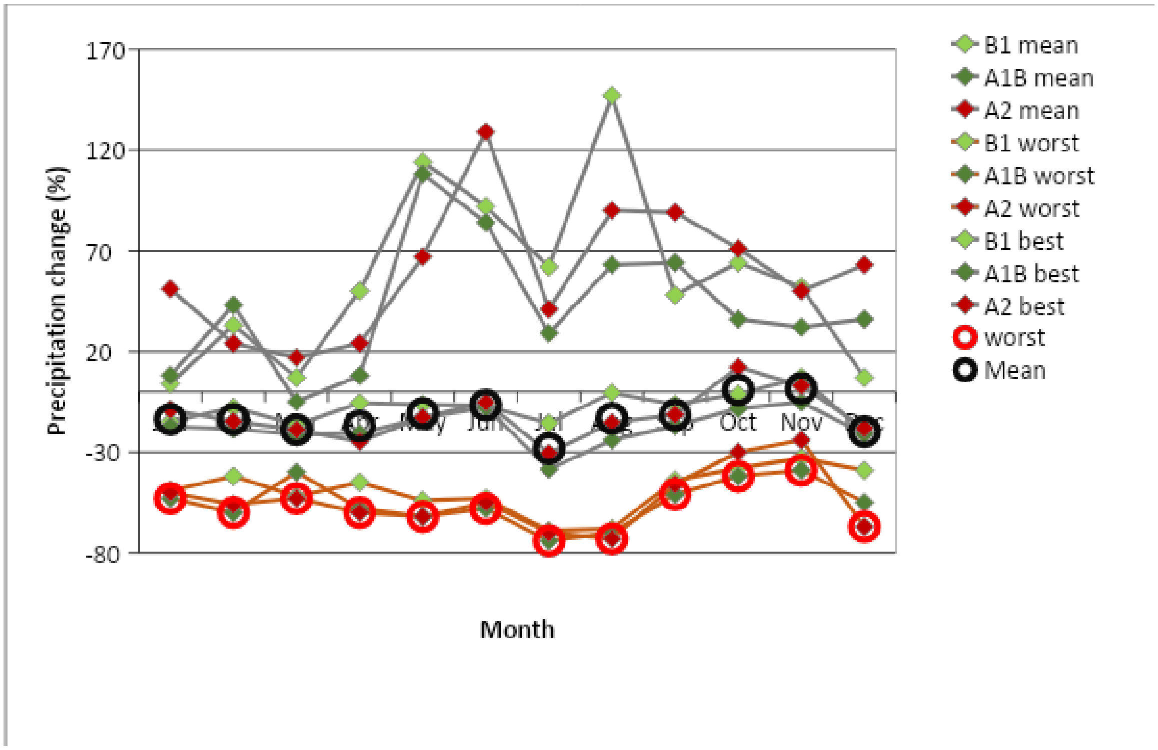


Figure 25. Deduced best, worst and mean ZK precipitation changes (2050).

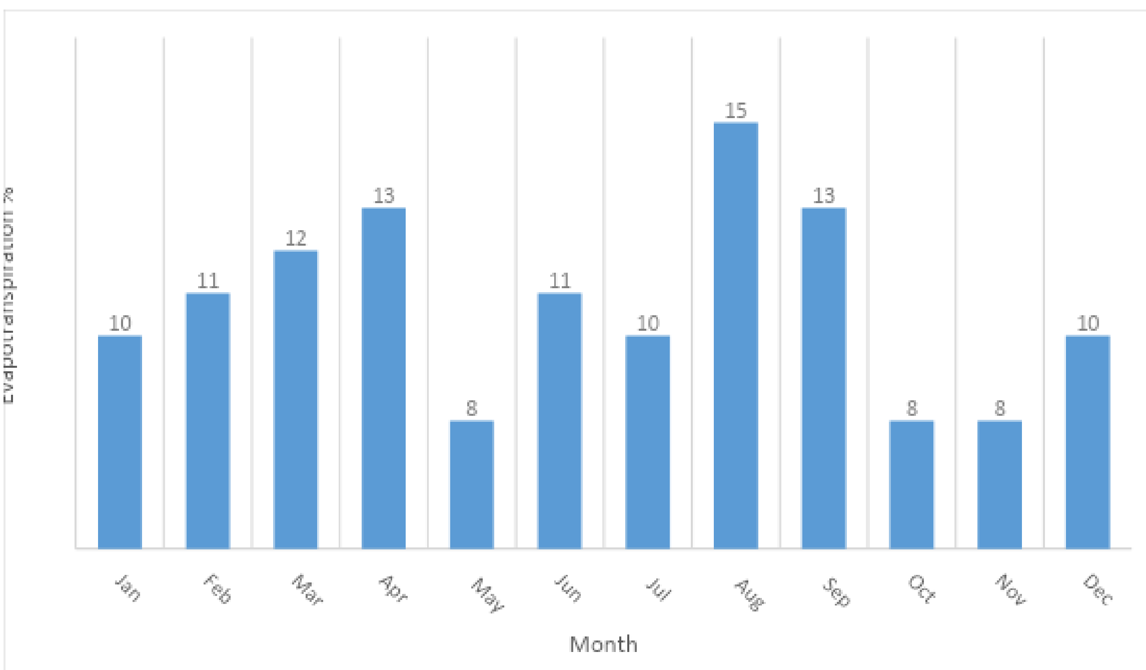


Figure 26. Mean future changes of evapotranspiration for the year 2050 (Lhomme et al. 2009).

Figure 27 and Figure 28 presents the geographic extends of shallow and deep aquifers. The study region covers large aquifers. The salinity parameter represents the main constraints facing the use of these resources for drinking and also for irrigation (*Figure 29*).

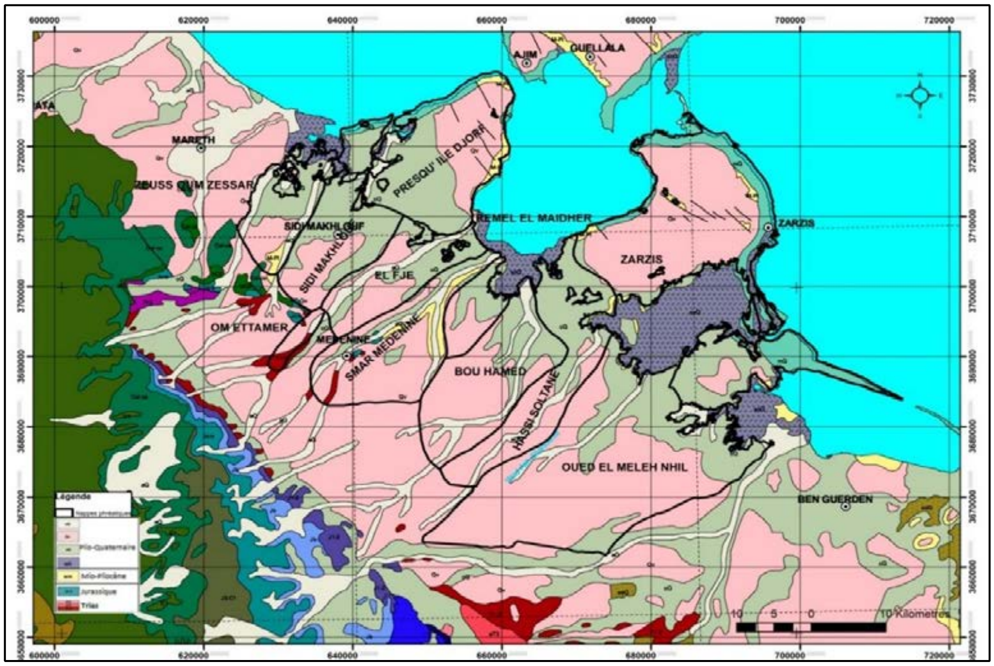


Figure 27. Shallow aquifers in the Djeffara of Medenine.

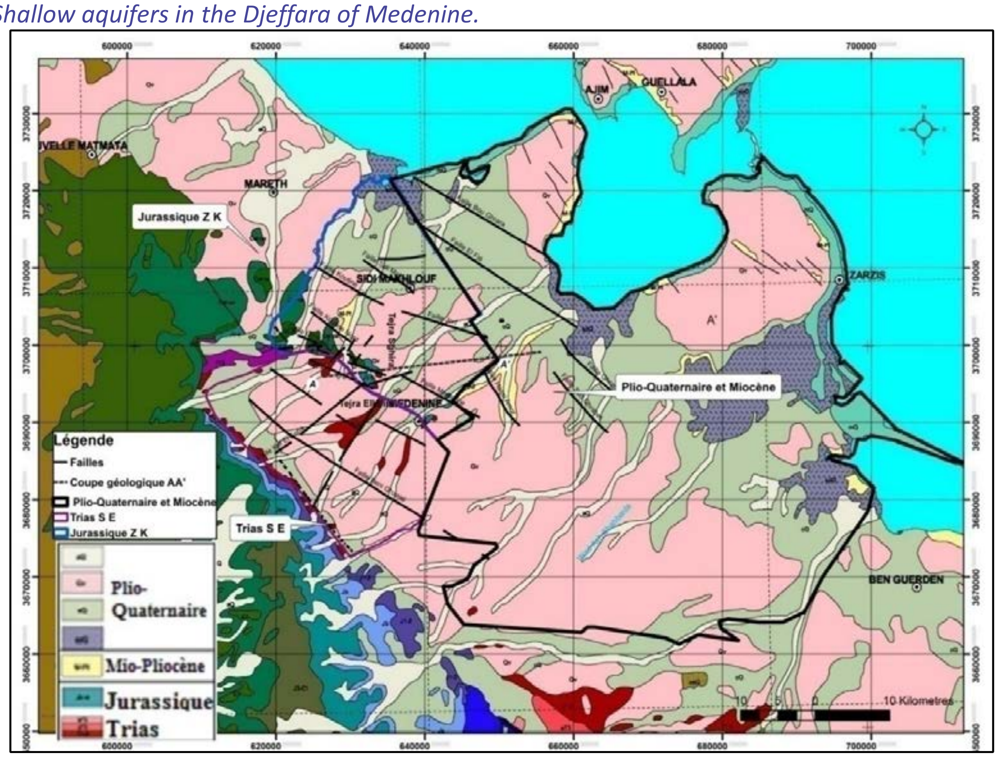


Figure 28. Deep aquifers in the Djeffara of Medenine.

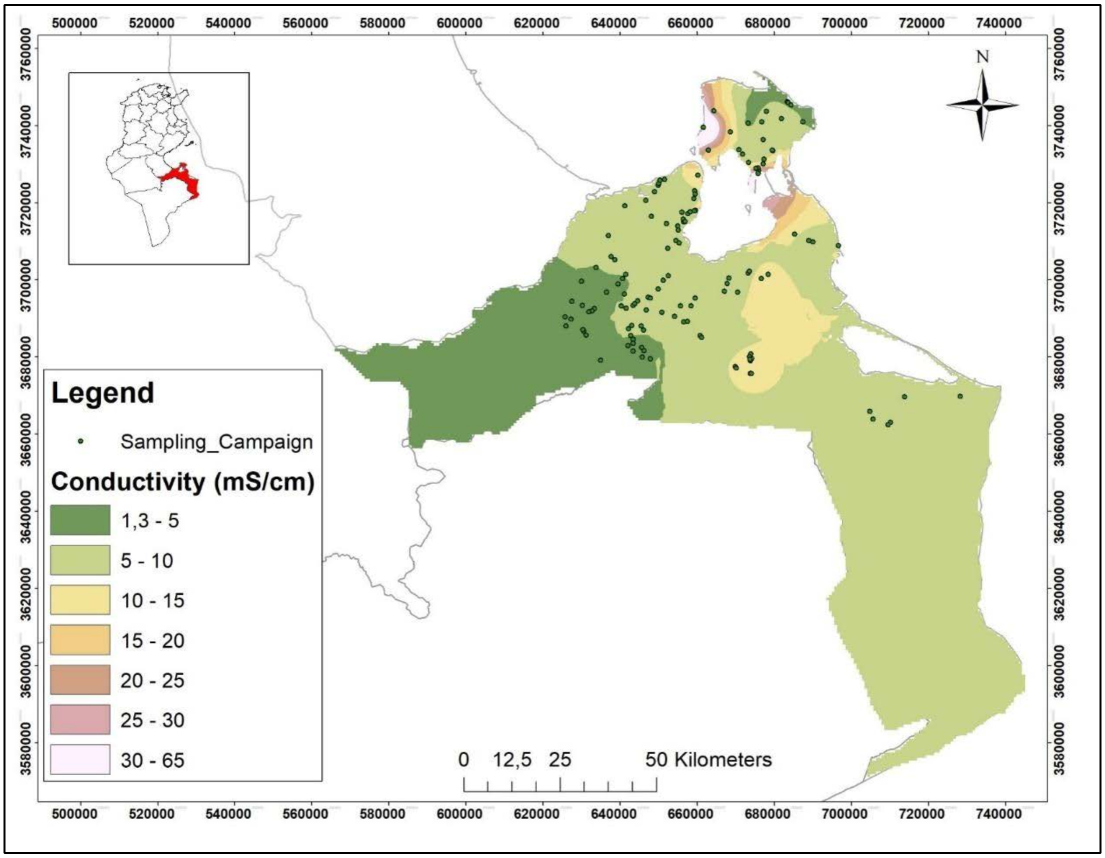


Figure 29. Groundwater conductivity map of the Djeffara plain.

For an average annual rainfall of 180 mm, the runoff volume in the Djeffara is estimated at 17.05 $10^6 m^3$/year.

The general directorate of water resources in Tunisia (DGRE), estimates the groundwater resources of fresh water in Djeffara shallow aquifers is about 12,67 10^6 m^3 in 2020. The following table summarizes the groundwater resources and uses in the Djeffara of Medenine:

Aquifer	Number of wells	Salinity (g/l)		Ressources	Pumping	Deficit	Use rate
		Min	Max	(Mm^3/y)	(Mm^3/y)	(Mm^3/y)	(%)
Zeuss-Om Zessar aval	131	4	7	0.79	0.3		37.97
BV Zeuss-Om Zessar - Hallouf	47	2,5	4,5	0.16	0.06		37.5
BV Om Tamar amont	160	3	5	0.63	0.54		85.71
Zarzis	341	4	7	0.94	0.87		92.55
BV Smar (Médenine)	815	3	8	1.39	3.08	1.69	221.58
BV Om Tamar (Fjé)	173	3,5	7,5	0.47	0.65	0.18	138.3
Presqu'île de Jorf	460	4	7,5	0.91	1	0.09	109.89
BV Sidi Makhlouf	128	4	8	0.5	0.33		66
BV Hessi Soltane	58	3,5	8	0.22	0.13		59.09
BV Remel el Maidher	60	4	8	0.66	0.23		34.85
BV Maleh-Nhil	104	4	8	0.18	0.19	0.01	105.56
BV Bou Hamed	95	4,5	7	0.47	0.29		61.7
Ile de Jerba	2328	2,5	8	3.46	3.88	0.41	112.14
Ben Guerdane	1065	5	8,5	1.89	2.82	0.93	149.21
Total	**5965**	**3.89**	**7.4**	**12.67**	**14.37**	**3.31**	**93.72**

Table 10. Water resources and used from shallow aquifers of Djeffara of Medenine- December 2020.

A diversified economy composed of agricultural, fishing and aquaculture activities, a renowned tourist pole, a nascent industrial fabric, craft activities and various small trades.

The region has an agricultural potential based on arboriculture and mainly olive groves which occupy 82.5% of the total cultivable agricultural area. Next table provides details about crops used and their areas in 2015:

CROP	Irrigated (I) &rainfed (R)	Area 2015 (ha)
barley (orge)	R	11465
Olives	R	197000
Almend	R	1415
Figs	R	1690
Pomegranates	I	155
Grapes	R	1395
barley (orge)	I	265
Millet	I	130
Olives	I	2010
Almends	I	1415
Forages	I	250
Piment	I	1.5
Tomate	I	2
Melon	I	1.5
Pastèque	I	2
Concombre	I	2
Courges/Courgettes	I	0.75
Legumes	I	1610
Vegetables	I	1770
Grapes	I	66

Table 11. Area occupied by crops (2015).

For the Djeffara water lab, the project team coordinated with the local administration of the Agriculture Ministry (CRDA Medenine) the project's implementation activities. To prepare ground for the TALANOA dialogue, INAT and CRDA Medenine agree on a four steps approach of pre-engagement:

- ✓ First, bilateral meetings (INAT-CRDA) were organized for the best understanding of the TALANOA project objectives and methodology, starting from September 2021. Field visits were also organized to optimize the study area geographic extent.
- ✓ In the second step, a first list of key stakeholders was set up and official letters sent, by INAT, inviting them to join the stakeholder platform, starting from February 2022. Most of them replied positively and a list of nominated persons is currently available. The main contacted stakeholders contacted by mail are:

- Medenine Governorate (GOV-MED),
- Office of South Development (ODS),
- Drinking water utility of Medenine (SONEDE),
- Sanitation office of Medenine (ONAS),
- Agency for Agricultural Investment Promotion (APIA),
- Region Union of Farmer and Fishery (URAP),
- Company for the Development and Investment in the South (SODIS),
- Agency for the Promotion of Industry and Innovation in Medenine.

✓ The third step consists of meeting with each of the invited stakeholders, and other candidates to the platform, taking the time to explain in detail the project objectives and methodological approach. While this activity started on Mars 2022, it was highly useful to engage in the project team a new actor: Institute of Arid Region of Medenine, through its socio-economic researcher, head of the economic department.

✓ The fourth step of the adopted approach consists of the organization of larger meetings involving the above engaged partners, with official letters and bilateral meetings, to start talking on the water lab organization and the role of each of the stakeholders. The first meeting was organized in June 2022, in the CRDA of MEDENINE. The project team was represented by the Water Lab coordinator (Dr. Issam Nouiri), the Water Lab rapporteur (Dr. Samir Sahal) and the socio-economist of the team (Dr. Mohamed Jaouad). The first science policy workshop was organized in September 2022 and the second was held at the Institute of Arid Regions in Medenine for two days from 08 to 09 March 2023.

The first science policy workshop was a real success to engage the main players of the water sector in the Djeffara plain (Figure 30).

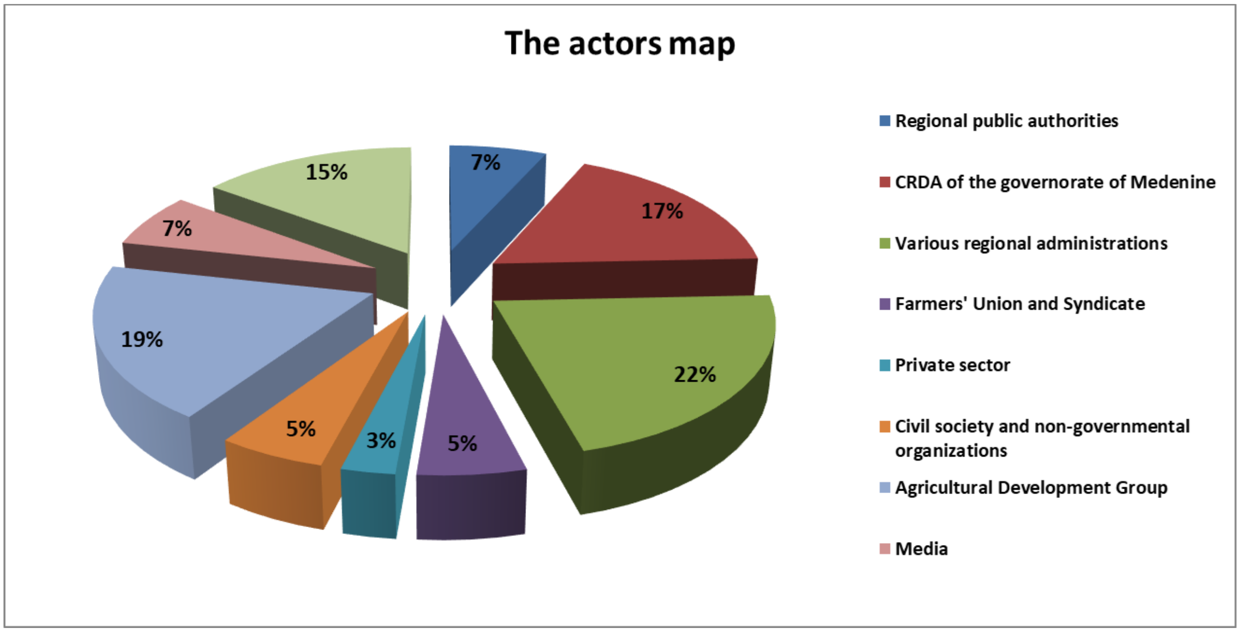


Figure 30. Map of the stakeholders engaged in the Djeffara water lab.

The following are photos of the dialogue groups during the first science policy workshop.

The second Science Policy workshop was organized during two days (08 and 09 March 2023) in Medenine with the participation of 47 stakeholders. The workshop put together the majority of the stakeholders of the water sector and deeply informed them about the main results of the first workshop, modeling methodologies and principles of the serious game. The list of stakeholders in the study area was enriched and validated. During the dialogue, there was general agreement on the need to update the approved data used in the modeling framework. There is a need to more involve the Statistics Service of the Regional Commissary for Agricultural Development of Medenine and the National Agency for Investment Promotion. The presentation of the modelling results during this WS was appreciated by all the participants. Training needs to be planned to further explain this framework in collaboration with the Spanish team (USAL). Problems related to water scarcity are more classified by priority. Three themes are validated by stakeholders: "Irrigated agriculture"; "Drinking water" and "Rain fed agriculture". The list of mitigation and adaptation measures and actions was edited. The mitigation and adaptation measures proposed are co-evaluated based on environmental, economic and social performances, and the cost of implementing each strategy was roughly estimated, for the serious game implementation. This evaluation needs to be more validated with the participants. The serious game was introduced and co implemented in the Djeffara Lab. The results will be more discussed in the next workshop. All news related to the project activities were posted on the Facebook page of the project (TALANOA WATER) to keep stakeholders involved, up to date and interested. The TALANOA-WATER project is now well known by the stakeholders of the water sectors in the Jeffara region.

2.5.2. Vision and Objectives

With the Tunisian water lab, we want to foster dialogue among all actors of the IWRM in the study area. In addition, our ambition is to build up a groundbreaking ecosystem of innovation based on transparent dialogue, modeling and experimentation. For this end, our team will implement the project activities to reach the following objectives:

- ✓ Identify and map stakeholders and build up a stakeholder platform where dialogue can be organized:

The mapping of stakeholders provides a reality check on the appropriateness and feasibility of the strategies of adaptation. They offer insight on and suggest methods to access the target populations, provide ongoing feedback and recommendations, and help make project results actionable.

A variety of actors are typically involved in TALANOA Dialogue Tunisian Lab which each of stakeholders can play various roles as described in Table 12:

Stakeholders identified at the beginning of the project	Regional administrations	The government bodies play a regulatory role and may also be involved in providing infrastructure or shared services, such as data access or setting standards for data formats for example.
	Scientific research	Researchers will disseminate all their knowledge through sharing the insights obtained with the other stakeholders in order to better develop the strategies identified.
	Civil society and non-governmental organizations	Civil society. NGO and other local groups/associations are important partners for generating information for the project and assisting in the economic, political, and social implementation of the results of the laboratory.
		Civil society actors are also important potential partners and sources of critical feedback on the planning and evaluation of the strategies identified.
	The private sector	Private companies are involved as part of their core business to identify and authenticate the main water consumers, their problems and their impacts.
	The media	The media plays an important role in the communication of information, shaping public awareness and providing ideas that shape attitudes and public opinion.
New stakeholders involved	The Agency for Agricultural Extension and Training	Have a direct contact with all the farmers.
	The Municipalities	They have a regional power and knowledge on social conflicts
	The Tunisian Electricity and Gas Company	Energy has been shown to play an important role in the exploitation of water resources

Table 12. The stakeholders involved and involvement status.

- ✓ Enhance knowledge of main actors on climate change risks, impacts, and adaptations strategies: During the first Policy Science Workshop, the presentations must aim to explain the current situation of water resources and the main risks of climate change. The discussions with the participants in the workshop have to lead to the identification of the main problems and solutions of water scarcity. These problems must be classified according to the type of water consumption for example: domestic, agricultural, tourist...etc. In addition to other problems related to the choice of crops appropriate to the type of soil, salinity, land problems… etc.

- ✓ Persuade the platform members to engage dialogue only based on experimental and modeling results and not on traditions: the meetings with the stakeholders will be based on the framework for water resources modeling developed by the Tunisian team. All the results of socio-hydrology modeling will be summarized and presented clearly to all the participants to co-design the most robustness strategies of adaptation.

- ✓ Identify and validate robust solutions for water scarcity and therefore improve citizen welfare: Participatory construction of the current landscape of water problems, co-design of sustainable scenarios and the co evaluating of adaptation strategies based on the results of water resources modeling should lead to robust solutions accepted by the community. Introduce the serious game as an innovative approach to co-design and choose robust transformational strategies.

- ✓ Transform the water scarcity problem on water jobs opportunities for youth and women in the region and showcase success stories for surrounding regions: Focus on solutions that create employment and income generating activities. Encourage innovative solutions, training, new technologies, simple applications...etc.

2.5.3. Strategy and Action Plan

As proposed in the concept note of the TALANOA-WATER project, we rely on the following three-pillar approach:

- ✓ Organize transparent dialogue among actors through bilateral and large meeting and in science-policy workshops,
- ✓ Develop a trustable modeling framework to serve as simulation tool to evaluate transformational strategies,
- ✓ Build-up an innovation platform, based on a water lab, where stakeholders will find answers for their questions related to water scarcity, technology, economy, and sociology.

A strong effort was developed to persuade actors to engage in a dialogue while there is a loss of trust on the already existing top-down relationships between the administration in charge of water management and the private sector, the non-governmental organizations (NGO) and the civil society. Indeed, it was involved in the TALANOA-WATER activities and in the dialogue with staff members of the regional research center (IRA de Medenine). In addition, frequent visits, and bilateral meetings as well as study tours were ensured by the project team.

Hereafter we summarize **Key Messages of the 1st Workshop Targeted to WPs** (and specific tasks)

WP1 – ENGAGE

1.1- The workshops put together most of the stakeholders of the water sector and deeply informed them about the project objectives, methodologies and expected results and outcomes.

For sustaining and enhancing the current engagement of stakeholders of the water sector, it is required to support their knowledge level on water problems/adaptation strategies through.

Message 1: Organize bilateral meetings during periods between workshops.

1.2- Dialogue among participants to the WP was split on thematic groups and moderated by members of the project team: Transparency and equilibrium are kept, and conflicts reduced.

Message 2: Organize thematic meetings to refine the co-design of transformational strategies.

1.3- The list of stakeholders in the study area was validated and enriched their main ones. Dialogue does not involve indicators for the track of the project progress: The project team needs to address this gap during the second round of dialogue, using appropriate support.

WP2 – DATA

2.1- During the dialogue, complementary data was provided by actors to convince others of their opinions (water user rates, water quality analysis, number of illegal wells …)

2.2- Hydrological data presented during the WS characterize well the history of the study region. There is a need for a deep analysis of scarcity and drought frequency in the region (use of drought indices, frequency analysis).

WP3 – MODELING

3.1- The dialogue during the first WS was focused on the water problems and solutions. While it takes three days, the high number of participants and their enthusiasm to discuss such subjects, do not allow them to tackle the modeling framework proposed by the project. The lab's modeling efforts and framework was detailed during the second science policy workshop for the main stakeholders, followed by discussions to validate the modeling approach and identify gaps.

3.2 The presentation of the results of the modeling during the second WS was appreciated by all the participants.

> *Message 3: Training needs to be identified during bilateral meetings and to be planned to more explain this framework in collaboration with the Spanish team.*

WP4 – LABORATORIES

4.1- Problems related to water scarcity are detailed and classified by priority for the main three themes chosen by stakeholders: "Irrigated agriculture"; "Drinking water", and "Rain fed agriculture".

4.2 The consensus of the evaluation of mitigation and adaptation measures proposed, and support decisions was established for each of the three-water problem's themes identified.

4.3 The mitigation and adaptation measures proposed are co-evaluated based on environmental, economic, and social performances, and the cost of implementing each strategy was estimated.

> *Message 4: Move to the implementation step of the co-designed adaptation strategies.*

4.5 The serious game was introduced and co-implemented in the Djeffara Lab.

> *Message 5: A second round with more elaborated information on the selected strategies and the use of the modeling framework.*

WP5 – EXPLOIT

5.1- All public and private media, present in the Djeffara region, participated in the dialog of the first science policy workshop of the TALANOA-WATER project.

5.2- The TALANOA-WATER project is now well known by the stakeholders of the water sectors in the Djeffara region.

5.2- All news related to the project activities were posted on the Facebook page of the project (TALANOA WATER) to keep stakeholders involved, up to date and interested.

Message 6: Start the exploitation of the dialogue results at regional and national level.

Message 7: Publication of findings on scientific papers and on international conferences.

https://www.facebook.com/profile.php?id=100085761925271

2.6. Egypt

As the II Workshop round for the EGY lab will take place after the present report completion, the following sections have not been updated yet from the I Workshop round. At the end of this chapter a synthesis of strategies and expectations regarding the II Workshop round has been reported.

2.6.1. Current Status

The Egyptian Water Lab is focusing on the Nile Delta, which is the terminal part of a 3.17 million km^2 wide river basin that spans 11 countries before joining the Mediterranean Sea in Egypt. Nile waters are diverted to irrigate 5.36 million hectares (Mha) of land basin-wide of which 3.4 Mha are to be found in Egypt (FAO, 2011) and around 2.27 Mha in the Nile Delta proper (MALR, 2011). In Egypt 55% of the population are dependent on the agricultural sector for their livelihood, a sector that accounts for about 15% of a Gross Domestic Product (GDP) of US$232 billion, and close to one-third of total employment (FAO, 2000).A dense network of waterways dissects the Nile Delta, including 40,000 km of canals that branch off the Nile River and convey water to over 2 million farmers across several nested geographical scales and institutional levels (van Achthoven et al., 2004). Intermingled with these conveyances' canals are 18,000 km of drains, where water is partially both reused by farmers and pumped back to higher-level delivery canals, and eventually conveyed to coastal lakes and the sea. As agriculture is the major user of water in Egypt, accounting for 85% of national demand, the question of irrigation-water-use efficiency over a range of scales (i.e., from on-farm to basin) is key to satisfying growing non-agricultural needs and possibly to expanding agriculture to provide livelihood opportunities for Egypt's rural population. Increasing the efficiency and equity of water use and management at all levels and also increasing agricultural productivity while conserving the resource base are the most salient objectives of both the National Water Resources Plan 2017 (MWRI, 2005) and the Government of Egypt's Strategy for Sustainable Agricultural Development 2030 (ARDC, 2009). Any discussion of the potential for increasing efficiency and how to achieve this is eventually linked to the question of the overall water availability. In other words, this starts with understanding how much water enters the Nile Delta, how it is then distributed, how much is drained to the sea, and whether this amount can be reduced to free up water for other consumptive uses, including more agriculture.

Total inflow into the Delta is 45 Bm³, including 42 Bm³ of Nile water, 1 Bm³ of rainfall, a hypothetical net depletion of 1 Bm³ of groundwater, plus 1 Bm³ of 'intrusion' (this last term, however, should not be computed as inflow since it is merely pumped out to the sea). The total of all diversions, adding reuse volumes, is around 63 Bm³ (42 Bm³ of Nile water, 7 of groundwater and 14 Bm³ of official/unofficial reuse). With an average of 13 Bm³ (minus 1 Bm³ consumed by aquaculture) flushed out to sea, the depleted fraction is (44-12)/44 = 73%. Most of this consumption is beneficial or unavoidable (evaporation of water bodies, navigation, unrecoverable drainage). If we assume that a minimum outflow of 8 Bm³ must be ensured, then only 4 Bm³, that is 9% of the water supplied (not including the 1 Bm³ 'intrusion' of saline water), could be made available for consumption by agricultural or non-agricultural processes (Figure 31).

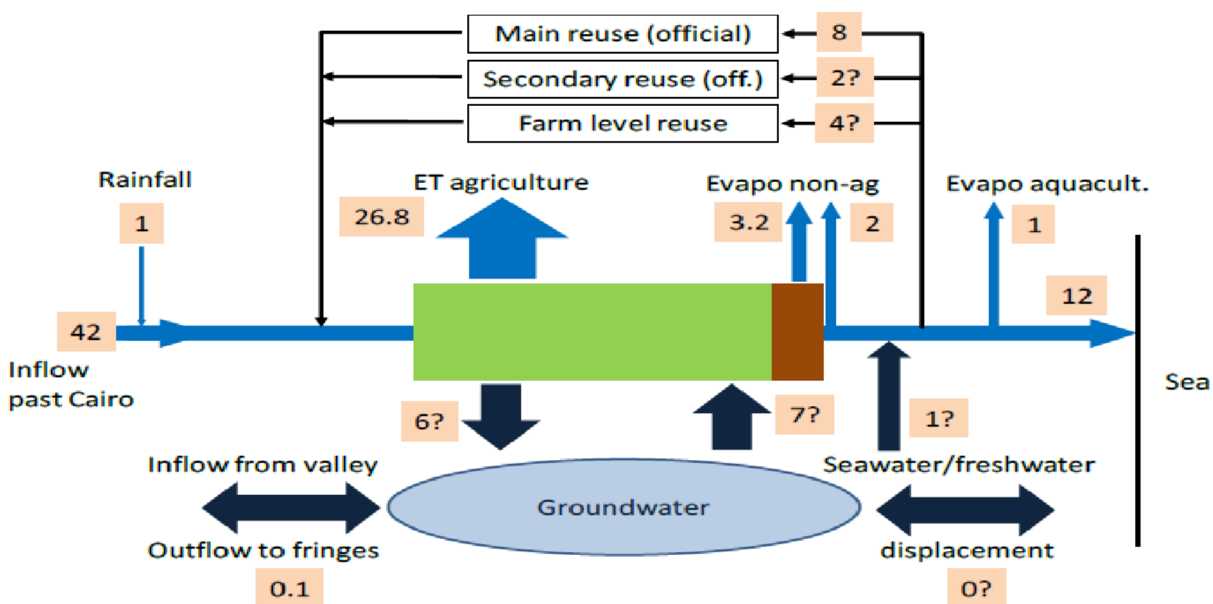


Figure 31. Tentative average water balance of the Nile Delta

In other words, this means that the Nile Delta system functions with an 'efficiency' equivalent to 93% of its potential, meaning that (31+10)/44= 93% of the water is consumed in either beneficial (agricultural or Municipal and Industrial Water - M&I: 31.2 Bm³) or unavoidable processes (8 Bm³ to the lakes + 2 Bm³ of water-body evaporation). This percentage is even higher if we consider the Valley and the Delta together because, with the exception of the drainage water lost to sinks in Fayoum (~0.7 Bm³), all the return flow in the Valley (whether superficial or underground) eventually reaches the Nile River again. Of the, say, 57 Bm³ released by the dam (plus 1 Bm³ of rainfall and 1 Bm3 of groundwater), 'only' (12-1) go to the sea (81% of water is consumed), while potential savings (3 Bm^3) make up only 5% of total releases.

A first observation is that this balance is not fundamentally different from that established in the late 1990s (Molden et al., 1996; Seckler, 1996) because inflow and outflow terms have remained largely stable. Changes include substantial growth in the role and use of groundwater, higher consumption of water by M&I, expansion of aquaculture and more intensive intermediate and unofficial reuse. The balance of the aquifer (-1 Bm^3 /y) is a key area of uncertainty and is not based here on hard science. We merely reproduce the official wisdom that abstraction is close to infiltrations estimated at 6 Bm^3. The lack of consistency in the data showing the movement of salinity isolines in the Delta (see maps in Morsy, 2009 and FAO, 2013) does not allow us to assume a higher net depletion of groundwater.

The field studies will be carried out in three sites located at the Western, Northern, and Eastern Nile Delta. The main problems and challenges facing the improvement of livelihood at the three selected sites are; (i) low performance and efficiencies of water supply networks, (ii) inequity of water distribution, (iii) water quality deterioration, (iv) poor irrigation and drainage management/practices, (v) soil compaction, (vi) shortage of inputs i.e. (fertilizers, new varieties … etc.), (vii) lack of financing/credit services, and (viii) absence of extra income-generating activities, (iv) seasonal water shortage, (v) poor drainage systems, (vi) reuse of low quality water (drainage water) in irrigation, and (vii) soil salinization. Surface irrigation is the dominant irrigation method for the cultivated crops. The land holders distributed into two classes, less than 2 ha at about 96% of the total number of holders and more than 2 ha representing 4% of the total number of holders. The paddy area is occupied the northern part of the Nile Delta, which characterized by heavy clay soils, waterlogging, and high-water table. Ultimately, rice cultivation is highly recommended in the northern part of the Nile Delta in order to protect the agricultural lands from the sea-water intrusion. The future of rice production in Egypt is governed by different factors such as the national policy of water management, the irrigation water shortage, the high-water salinity of the Northern part of the Nile Delta, and the high profit of rice cultivation (Ghassemi et al. 1995).

1. The Western Nile Delta Site:

The average rates of the main meteorological parameters ranged between 14^0C to 29^0C of temperature, 52% to 65% of relative humidity, and 98 mm to 114 mm of annual rainfall. Soil at the site can be classified as good and moderate. The main cultivated crops are berseem, wheat, broad bean, vegetables in winter, and maize, cotton, and rice in summer.

2. The Northern Nile Delta Site:

The average rates of the main meteorological parameters ranged between 19.2 ^{0}C to 32.3^{0}C of temperature, 56% to 72% of relative humidity and 60 mm to 80mm of rainfall. Soil at Sakha site is fertile and classified as heavy clay soil with a high water table. The cropping pattern of the study area is faba bean, berseem, sugar beet, wheat, and vegetables in winter, but it is rice, maize, cotton, and some medicinal plants in summer.

3. The Eastern Nile Delta Site:

The average rates of the main meteorological parameters ranged between 21.2^{0}C to 37.3^{0}C of temperature, 66% to 76% of relative humidity and 60 mm to 80mm of rainfall. Soil can be classified as good soil, moderate and poor. The main cultivated crops in winter are berseem, wheat, broad bean, sugar beet, flax, and vegetables, where cotton, maize and rice are the main summer crops and represent about 60% of the total cultivated area, in addition to some ornamental and medicinal plants.

Water dynamics in the Delta and the corresponding quantitative mass balance cannot be evaluated without a corresponding analysis of the salt balance. Depending on water management practices salt may accumulate in both the soil and specific drains, which may impair agriculture and prevent conjunctive use. In a survey undertaken in 1991, the Total Dissolved Solids (TDS) in Nile water recorded upstream of the Delta barrage ranged from 246 mg/l in May to 410 mg/l just before the peak of the winter closure period (January). A survey in 2002 showed how TDS gradually increased from 171 mg/l downstream of HAD to 240 mg/l at the Delta barrage and then to 450 mg/l along the 80 km of the Rosetta branch (APP, 2008). If we assume that there is no net increase in the salt load along the Nile Valley, then the 171/240 ratio (= 0.71) gives an estimation of the percentage of the water released from HAD that reaches the Delta without being consumed on the way. The sharper increase along the Rosetta branch is due to the incorporation of drainage return flow from the central Delta.

Figure 32 shows the spatial variability of drain-water salinity in the Meet Yazid command area in summer (El-Agha et al., 2015c): the greater part of the upstream command area of Meet Yazid has a drainage water salinity under 1,400 µmhos, with the exception of an area near Matboul, where salinity is between 1,400 and 2,500 µmhos. This is a low-lying area, which actually has to be drained by a large-scale pump station. Medium salinity is observed on the western part, in the W10 area, which can be explained by the fact that this area is predominantly fed with drainage water from the Nashart drain, which has higher salinity (IWMI and WMRI, 2013). Figure 32 indicates a growing salinity as one moves northward, until the Moheet drain that defines the limit of the agricultural area. Interestingly, the command area of the Abu Mustafa canal, in the middle of the command area, produces drainage water with salinity under 2,000 µmhos, which contrasts with adjacent areas, where salinity varies between 2,000 and 4,500 µmhos. The Ghabat and Halafy drains, to the east, exhibit a clear pattern of growing salinity as one moves northward, indicating a south-north gradient of soil salinity compatible with the fact that, historically, flooding, impoundment and seawater influence were more pronounced and prolonged towards the sea.

2.6.2. Vision and Objectives

In Egypt, under limited water supply conditions, providing additional resources through desalination or other means will be an expensive option. Therefore, efforts towards the optimal management of available water resources should concentrate on the demand management side. As the agricultural sector is consuming the bulk of water supply, good management of irrigation water can be translated into significant savings in the available water resources. In addition, the agriculture sector will be the most affected by anticipated future water shortages and will be expected to relinquish water to other uses such as the domestic and the industrial sectors. Consequently, increasing the efficient use of water in the agricultural sector is an overarching goal driving policy changes and promotion of new technologies targeting improvements in on-farm water management and maximization of agricultural return per unit of water. In the last two decades, replacing surface irrigation with precise irrigation systems became the main interest of the decision makers and policy planners in Egypt. Land fragmentation, capital and operating costs, profitability, and the need for qualified labor are the main challenges in converting from surface to pressurized irrigation systems. Rather than converting, surface irrigation systems can be upgraded to perform as efficiently as most other irrigation methods using hybrid techniques. To achieve higher efficiency and uniformity in the surface irrigation systems, all parts of the irrigated field should receive water for a near equal period of time, with a minimum of water losses to runoff or to deep percolation below the root zone. A range of practices, including land leveling, reuse of tailwater (i.e., reuse of water that runs off the downstream end of surface irrigated fields), raised beds, cutback irrigation, and surge-flow irrigation can be employed to improve the effectiveness of surface irrigation. These best management practices and strategies can all contribute to improving the efficiencies of surface irrigation, but these measures still do not enable the performance of the surface irrigation to match that of the pressurized irrigation methods.

In Egypt, rice provides 27% of dietary energy supply and 20% of dietary protein intake, therefore, enhancing the productivity of rice will alleviate poverty, eradicate hunger, and contribute to the national food security and economic development. Consequently, rice has become one of the most important exports in the agricultural sector. The area cultivated with rice is growing gradually in the Nile Delta. It increased from about 280,000 ha by the mid-70's to about 0.8 million ha in 2022. This rapid increase in rice cultivation has resulted from its increasing profitability compared to other crops. The drastic increase in water use for rice cultivation is augmenting the pressure on water supplies; it consumes about 29-50% of the total water budget of Egypt and threatens to undermine the availability of water for reclaiming new lands. In light of this, innovative ideas such as hybrid irrigation, multi-nozzle sprinkler irrigation, and surface and subsurface drip irrigation technologies, as well as raised bed and system of rice intensification (SRI) practices will be adopted to modernize and further increase the efficiency of surface irrigation systems and rice productivity.

The overall goal is to optimize water use in the paddy area of Egypt and to increase crop water productivity, in order to achieve food security, alleviate poverty, eradicate hunger, decrease the negative environmental impacts of rice irrigation, and contribute to the national income development.

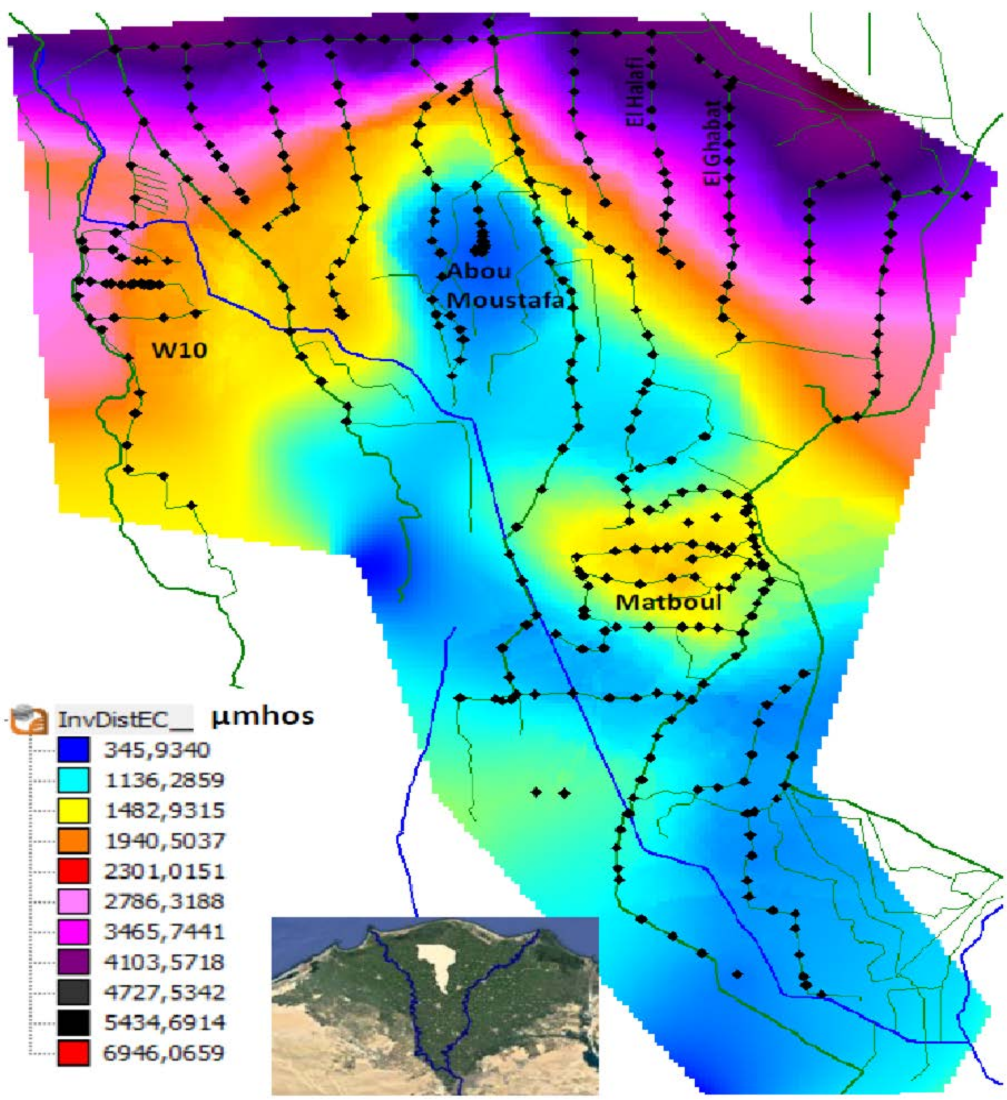


Figure 32: Water salinity in drains – summer 2014 (in µmhos)

2.6.3. Strategy and Action Plan

The Talanoa Dialogue drives co-generation ground on to the interaction and engagement with involved Stakeholders, spread through a wide set of groups, both collaborating and competing in the water resource allocation. Our approach goes in-line with the Talanoa Dialogue ambition. We will be able to co-identify, alongside the key stakeholders, science-based policies that will emerge from an open dialogue and collaborative interactions. Our efforts will focus on the following adaptation strategies (Table 13).

Proposed Adaptation Strategies	Additional Adaptation Strategies	Modelling Activities
Adoption of bio-saline crops	Improve crop water productivity through efficient irrigation systems such as Hybrid Irrigation	ALESARID Model
Mobile-based irrigation service sensors, metering and remote sensing	Implement long-term water resources planning via water accounting	Microeconomic Model
International filling and operation agreement between Ethiopia, Sudan and Egypt for GERD (If the political situation makes it possible)		SALTMED Model

Table 13. The proposed and added adaptation strategies of the Egyptian Lab

While organizing the incoming II WS round planned for the end of June, the implemented adaptation and mitigation strategies at the Egyptian Water Lab were modified based on the recommendations of the 1st stakeholder workshop of TALANOA-WATER, held in the form of three consecutive training workshops, 5 days each, during May/June 2022.

Particularly, recommended adaptation and mitigation strategies were: 1) Improving rice water productivity through efficient irrigation systems such as Hybrid Irrigation; and 2) Implementing long-term water resources planning via water accounting.

The overall goal of the 2nd workshop is thus to present the findings of the field experiments conducted on applying climate resilient innovative irrigation technologies and practices for enhancing rice water productivity in the Nile Delta.

The suitable time for holding the workshop is during the growing season of rice, which starts in June and ends in October, this is because the workshop will focus on the rice crop and will be followed by a field visit. This also explains why the WS has been delayed compared to other labs and initial expected timeline.

The workshop will be very interactive in nature and involve all impactful stakeholders and policymakers holding senior positions in the public and private sectors, as well as in international organizations.

The stakeholders are representatives of the Ministry of Water Resources and Irrigation, Ministry of Agriculture and Land Reclamation, Faculties of Agriculture, FAO, ICARDA, Canadian International Aid, Farmers Associations, Irrigation associations, etc. The workshop will consist of a series of presentations by the organizers briefing the advances of the TALANOA-WATER project in which stakeholders participated in developing water policies and strategies and familiarize with the results.

In addition, the 2nd workshop will take care of responding to the following key messages of the 1st workshop:

3.1- A set of recommendations and suggestions were provided by the participants to be considered within the modeling approach. These recommendations and suggestions include but not limited to 1) developing a package of innovative irrigation technologies and strategies for sustainable rice production in the Nile Delta because rice is the main historical, profitable crop in the region; and 2) recommending an alternative cropping patterns to:

- adapt to the expected sea water intrusion which will affect the soil quality of the entire Nile Delta; and
- mitigate to water shortage due to the dilemma of the Ethiopian GERD

Hereafter we summarize **Key Messages of the 1st Workshop Targeted to WPs** (and specific tasks)

WP4 – LABORATORIES

4.1- The data collected from the participants in the workshop via the designed questionnaires were analyzed. And, the recommendations related to water scarcity and climate change were identified by priority for additional adaptation and mitigation strategies chosen by stakeholders, to be implemented by the Egyptian Lab side by side with the proposed strategies of the project, which are: 1) Improving crop water productivity *through efficient irrigation systems such as Hybrid Irrigation; and 2) Implementing long-term water resources planning via water accounting.*

4.2- Five field experiments were conducted to collect the needed data for formulating the essential adaptation and mitigation strategies of the project and the additional strategies suggested by the stockholders.

4.3- Three models were selected (i.e. ALESARID Model, Microeconomic Model and SALTMED Model) to be used to support the evaluation of the mitigation and adaptation measures proposed to support decision makers and policy planners.

WP5 – EXPLOIT

5.2- The project findings and achievements will be shared with the stakeholders during the coming workshop. Therefore, leaflets of the outcomes of the project will be prepared before the 2nd national workshop.

2.7. Conclusions: taking stock, looking forward.

24 months into the project implementation, the Talanoa Water Dialogue is developing successfully. All stakeholder engagement activities have been initiated, and the dialogue is being continuously monitored at a lab level by lab leaders, and at a Consortium level through the Champions Team. An answer to the first crucial question **"Where we are** "has been provided and validated with stakeholders in each of the 6 laboratories, by identifying:

- The climate variability and expected Climate Change (CC) trends in each lab.
- Threats posed by CC to water availability, from available sources, focusing on water scarcity.
- Hydrology and water management, context (data on hydrology and water resources/ demand relevant for the lab.
- Relevant economic sectors involved, focusing on those exposed to water scarcity and likely more impacted.
- The stakeholder's involvement status and characterization, pointing out mandates/responsibilities and interests, and interdependencies.

All the Labs are also addressing the other relevant questions underpinning the Talanoa Water Dialogue, framed during the first round of science-policy workshops and substantiated through the work of the Consortium and during the second round of workshops.

Answering the question "**Where Do We Want to Go**" has been done initially by identifying and addressing the climate, hydrological, agronomic and socioeconomic knowledge needs and models, as well as the challenges faced in the labs to address these needs and collecting the required data to run models.

Potential and realized conflicts around water use that emerged have been addressed in labs through Talanoa dialogue-inspired interactions including serious gaming in the second round of workshops. Stakeholder engagement allowed the Labs to achieve their ambition of exploring, through TALANOA Water dialogue, sustainable *trajectories* for water use through co-designed adaptation policies, whose performance has been assessed under alternative plausible scenarios (see also D3.2).

Stakeholder engagement was highly instrumental in identifying a roadmap to achieve the project objectives and address possible gaps, thus answering the **"How do we get there "question**. To this end, Labs have identified relevant ecological and socioeconomic knowledge and experience of stakeholders, trained on the TALANOA-WATER ecosystem of innovation and modeling framework, and facilitated the integration of the project modeling tools into the Decision Support Systems and models already used by stakeholders.

Lab's activity aimed at enhancing the understanding of complex socioecological problems, as well as stakeholders' skills in climate change and socio-hydrology modeling, particularly the interpretation of modeling outcomes, so as to facilitate understanding of possible adaptation policies tested/to be tested using TALANOA-WATER models (and eventually adopted).

The second round of workshops investigated this aspect further by combining local stakeholder knowledge (heuristics extracted from stakeholders' expertise) and hydrologic/socioeconomic models (elaborated by researchers including stakeholders' models) in the co-design of adaptation strategies and in decision making processes, with attention to replicability of the proposed solutions to broader contexts.

During the TALANOA-WATER dialogue process, some limitations and challenges have been identified, such as establishing trust among researchers/practitioners and stakeholders, addressing underrepresented stakeholder groups, ensuring gender balance, and maintaining stakeholder engagement while improving communication. To overcome these challenges a set of suggestions and key messages have been formulated, incorporating feedback from stakeholders to further support effective implementation and addressing the specific needs of each lab.

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Annex 1 - Used Performance Indicators and Workshops indicator's summary table

Hereafter follows a list of all the indicators used to keep track of progress in stakeholders' engagement through Talanoa Dialogue, as agreed on during the Champions Team early meetings, following Table 14 resumes the status of indicators through the Workshops held until the present Report is written.

Indicators with focus on balanced and inclusive involvement

- Share of women that are part of the water laboratories (attending, reporting, contributing) and WS.
- Number of gender dis-aggregated feedback (particularly on adaptation strategies) collected during the workshop.
- Number of different types of organization involved in the Laboratories.

Stakeholders' involvement indicators

- Numbers of cards/ideas/tools used to collect feedback in the workshops (e.g., questionnaires, boards, games) listed in the minutes.
- Number of specific feedbacks collected towards WPs in the workshops.
- Overall duration (number of days) of stakeholders' meetings carried out in the laboratory between each workshop.
- Number and type of other channels for interaction with stakeholders (besides meetings/workshops such as mail, social media groups) + number of interactions per year.

Indicators on WP response to Stakeholders

- Number of specific feedbacks addressed in WPs before next workshop.
- Number of feedback surveys collected from stakeholders on their involvement (e.g. WP1 post-workshop feedback and WP1 mid-term feedback from the stakeholders on the level of engagement, could be anonymous).

- Number of stakeholder models incorporated into the modeling framework in WP3 (e.g., AQUATOOL in Spanish lab).
- Number of scenarios co-designed by Stakeholders modeled in WP3 (and % over total scenarios simulated - ideally it should be 100%).
- Number of TAP (Transformational Adaptation policies) co-designed by stakeholders modeled in WP3 (and % over total TAPs simulated - ideally it should be 100%).
- Number of TANALOA representatives participating in events organized by stakeholders.
- Number of meetings (including workshops) shared minutes validated with stakeholders (for WP4)
- Number of communication outcomes (press releases, twits, posts, articles...) produced directly by a Stakeholder, including the number of communication outcomes directly from water labs (for WP5).

n.	Indicators	Italian Workshop 1: 29-07-2022	Lebanese Workshop 1: 13-07-2022	French Workshop 1: 16-06-2022	Spanish Workshop 1: 29-30/09/2022	Tunisian Workshop 1: 21-23/09/2022	Egyptian Workshop 1:09/06/2022	Italian Workshop 2: 29-03-2023	French Workshop 2: 09-03-2022	Spanish Workshop 2: 13-14/04/2023	Lebanese Workshop 2: 27-04-2023	Tunisian Workshop 2: 08-09/03/2023	*Egyptian Wo 24/06/2023*
	Indicators on balanced and inclusive involvement												
1	% of women that are part of the water laboratories (attending, reporting, contributing) and WS	8 women / 12 participants (66%)	4 women / 15 participants (=27%)	14 women / 36 participants (=39%)	6 women / 30 participants (=20%)	13 women / 67 participants (=19%)	16 women out 76 participants (21%)	*4 women / 12 participants (33%)*	*15 women / 44 participants (34%)*	*2 women / 18 participants (=11%)*	*6 women / 13 participants (=46%)*	09 women / 47 participants (=19%)	40 women out of 75 were invited for participation (=53.3%)
2	Number of gender dis-aggregated feedback (particularly on adaptation strategies) collected during WS	3 from W, 2 from M	2 from W, 6 from M	>20	4 from W, 11 from M		none	*3 from W, 3 from M*	*>40*	*2 from W, 14 from M*	*7 from W, 4 from M*	3 from M and open discussion on the evaluation of the 3E of strategies	Not Yet
3	Number of different types of organization involved in the Laboratories	6	11	8	15	7	9	*6*	*9*	*8*	*11*	10	15
	Indicators on stakeholders' involvement												
4	Number of cards/ideas/tools used to collect feedback in the workshops (e.g. questionnaires, boards, games) listed in the minutes		5 rounds of discussions	5 interactive sessions with cards/boards; sketching; questionnaire; presentations	2 questionnaires, 1 serious game	Factsheet for each group (4 boards) & 10 presentations	90 questionnaire and 60 presentations	*5 users ppt*	*3 interactive sessions with cards/boards/maps; sketching; questionnaire; presentations*	*2 questionnaires, 3 serious games*	*2 live polls (Mentimeter); 3 strategy selection surveys; 2 survey rounds; 4 presentations; 1 dossier*	2 questionnaires for strategies, 3 serious games, 1 survey to evaluate the workshop	4 interactive sessions with 8 presentations

n.	Indicators	Italian Workshop 1: 29-07-2022	Lebanese Workshop 1: 13-07-2022	French Workshop 1: 16-06-2022	Spanish Workshop 1: 29-30/09/2022	Tunisian Workshop 1: 21-23/09/2022	Egyptian Workshop 1:09/06/2022	Italian Workshop 2: 29-03-2023	French Workshop 2: 09-03-2022	Spanish Workshop 2: 13-14/04/2023	Lebanese Workshop 2: 27-04-2023	Tunisian Workshop 2: 08-09/03/2023	*Egyptian Wo 24/06/2023*
5	Number of specific feedbacks collected towards Work Packages in the workshops	6	6 problems identified, 3 ideas on strategies proposed	7 ideas on strategies/instruments & future scenarios.	>10 transformational adaptation strategies identified;	6 targeted indications	3 ideas on strategies & future scenarios.	6	*5 aggregated WP*	*5 aggregate WP suggestions*	*6 WP-directed suggestions*	7 targeted indications	It's expected to have 6 WP-directed suggestions
6	Overall duration (number of days) of stakeholders' meetings carried out in the laboratory between each workshop	0.5	0.5 with Litani River Authority		2 meeting days (Douro RBA, Ministry)	3+1 meeting days	3 meeting days	0.5	*2 events (i)COPIL =core group of stk) and (ii) NBS workshop*	*1 meeting days (Douro RBA)*	*2 meeting days (Litani River Authority and Farmer)*	2 meeting days (in December 2022 at IRA)	3 meeting days
7	Number and type of other channels for interaction with stakeholders (besides meetings/workshops such as mail, social media groups) + number of interactions per year	10 mail exchanges, 4 direct phone calls, 1 WS	7 email exchanges; 10 posts 6 phone calls; 5 social media channels engagement	bilateral mails; Facebook group; internet page (to come)	38 letters of invitation; 335 email exchanges; 14 direct phone calls; 1 meeting; 9 WhatsApp messages.	93 letters of invitation (72 per email & 35 invitations per fax); 35 direct phone calls;	10 letters of invitation (WhatsApp messages)	*20 mail exchanges, 5 direct phone/web calls, 1 WS, 1 miro board*	*bilateral mails; Facebook group; internet page; 1 Workshop on Agroecology*	*38 letters of invitation; 96 email exchanges*	*11 invitation letters; 72 Email exchanges; 10 direct phone call /WhatsApp exchanges*	47 letters of invitation; 47 email exchanges	75 letters of invitation (emails and WhatsApp messages)
	Indicators on WP response to Stakeholders												
8	Number of specific feedbacks addressed in WPs before next workshop	1	2	not yet	11 (10 transformational adaptation strategies, macroeconomic model incorporated)	not yet	3	*4*	*1*	*1*	*4: measures /adaptation strategies into a serious game + incorporating engaging dialogue tools+live polls+further communication of lab project*	not yet	not yet

n.	Indicators	Italian Workshop 1: 29-07-2022	Lebanese Workshop 1: 13-07-2022	French Workshop 1: 16-06-2022	Spanish Workshop 1: 29-30/09/2022	Tunisian Workshop 1: 21-23/09/2022	Egyptian Workshop 1:09/06/2022	Italian Workshop 2: 29-03-2023	French Workshop 2: 09-03-2022	Spanish Workshop 2: 13-14/04/2023	Lebanese Workshop 2: 27-04-2023	Tunisian Workshop 2: 08-09/03/2023	*Egyptian Wo 24/06/2023*
											activities		
9	Number of feedback surveys collected from stakeholders on their involvement (e.g. WP1 post-workshop feedback and WP1 mid-term feedback from the stakeholders on the level of engagement, could be anonymous)			19 feedback surveys	6 questionnaires: 1 logistics, 2 delphi, 2 serious games, 1 feedback		9 questionnaires	*4*	*21 feedback surveys*	*6 questionnaires: 1 logistics, 2 delphi, 3 serious games*	*10 feedback surveys*	6 questionnaires: 1 logistic, 2 for problems and solutions before and after serious game, 3 serious games	3
10	Number of stakeholder models incorporated into the modeling framework in WP3 (e.g., AQUATOOL)		1		1 (AQUATOOL)	1	2: ALES-ARID and SALTMED	*1 ARPE-CMCC hydrologic model in CC*		*1 (AQUATOOL)*	*2*	1	2
11	Number of scenarios co-designed by Stakeholders modeled in WP3 (and % over total scenarios simulated - ideally it should be 100%)		1	not yet validated but topic was addressed in the WP. will be reworked in a ws on the 9th of dec	10	3	3		*4 scenarios (not yet simulated)*	*10*	*3*	9 (100%)	3
12	Number of TAP co-designed by stakeholders modeled in WP3 (and % over total TAPs simulated - ideally it should be 100%)			not yet validated but topic was addressed in the WP. will be reworked in a ws on the 9th of dec	10+		3		*the workshop produced 4 preliminary TAPS, will be further elaborated (selected for modeling)*	*10+*	*3*		3

n.	Indicators	Italian Workshop 1: 29-07-2022	Lebanese Workshop 1: 13-07-2022	French Workshop 1: 16-06-2022	Spanish Workshop 1: 29-30/09/2022	Tunisian Workshop 1: 21-23/09/2022	Egyptian Workshop 1:09/06/2022	Italian Workshop 2: 29-03-2023	French Workshop 2: 09-03-2022	Spanish Workshop 2: 13-14/04/2023	Lebanese Workshop 2: 27-04-2023	Tunisian Workshop 2: 08-09/03/2023	*Egyptian Wo 24/06/2023*
13	Number of TALANOA representatives participating to events organized by stakeholders		2	2	13		1		*2*	*1*	*2*	1	2
14	Number of meetings (WS +) shared minutes validated with stakeholders (for WP4)	1		1	1	not yet		*1 (WS minutes)*	*2*	*2 (WS minutes)*	*1*	1 (WS minutes)	1
15	Number of communication outcomes (press releases, twits, posts, articles...) directly from Stakeholder, including the number of communication outcomes directly from water labs (for WP5)		3 (AUB main, faculty, & lab websites); 1 (STK Instagram Post-Rapporteur); 3 (Tweets); 3 (LinkedIn posts)	2 Tweet; 1 news on INRAE site; 1 linkedin; 1 press (to come in nov22)	1 Instagram, 10 Twitter posts (2 Original tweets, 8 Retweets), 3 LinkedIn posts	4 articles published in 2 regional radios and 1 on a national radio (website & Facebook page) intervention in a direct broadcast, farmer section /video		*not yet, channels collected*	*2 (newsletter from a coop - ARTERRIS, TV itw on France 3)*	*Not yet*	*2 LinkedIn posts; 2 Tweets; 1 blog post on lab's website; 1 university faculty news*	2 Facebook posts	not yet
16	Number of participations of TALANOA water lab PI/partners in WSs of another water lab		1 (Spanish Lebanese participation)							*4*	*2*	2	not yet

Table 14. - outcomes of the Champions Team indicators after both the first and second rounds of workshops (planned workshops and expected results in Italic), self-evaluation table developed by Lab leaders.

Annex 2 - The Spanish 2nd Workshop's serious game session

In the Spanish 2nd Workshop, new models (microeconomic ensemble) were calibrated and results from simulations adapted into a devoted serious game session (**serious game 2**). In this second version of the serious game a board game with cards was adopted. The aim of this second serious game was to assess the differences between simulated farmers' behavior and the actual behavior emerging in the game played by the stakeholders.

In order to reach the final version of the game, 10+ testing games were carried out with different players (i.e., members of the TALANOA-WATER Spanish Water Lab, students and professors at the University of Salamanca) to improve the game experience. Most of the difficulties found during the tests were due to the logical interaction among the different authorities, such as the Ministry and the WBA. Uncertainty was implemented in the form of contingency cards, through which farmers could experience positive or negative effects on the gross margin of their crops, based on observed gross margin fluctuations from historical data.

The game was structured as follows:

Players: 6+ players: Ministry of Agriculture (1), Farmers (4+), Water Basin Authority (WBA) (1), plus a game-master (a researcher from the Consortium). Below we report the objective and the role of each player:

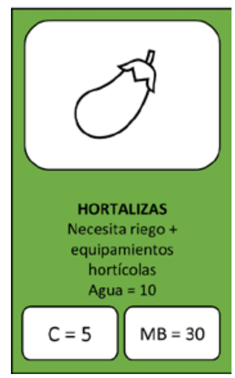
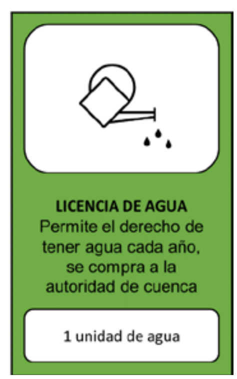
- Ministry of Agriculture. Objective: (sustainable) development of the agricultural sector. Roles: (1) sells land, (2) sells seeds, (3) can hand out subsidies to other players (to farmers for land/seeds acquisition and modernization, to Water Basin Authority (WBA) for acquisition of remote sensing devices)
- Farmers (at least 6-7 farmers if water theft option is activated). Objective: maximize income and minimize risk. Roles: (1) they can grow 3 crops (Water intensive/high return and risk, moderate water intensive/medium return and risk, rainfed/low return and risk), which are based on real data from AWDUs of Cega lab. (2) They buy land seeds from the Ministry and (3) sell their harvest to the game master. (4) They have to pay (fixed + variable levy, if the latter is adopted by the WBA) the WBA for water (although they can illegally irrigate without a license), and (5) to irrigate their crops they must have the irrigation equipment (sold by the game master). Moreover, (6) they must purchase other equipment (from the game master) to plant the more profitable crop (called "horticulture equipment" such as greenhouses).
- WBA. Objective: conserve the good ecological status of the river. Role: the WBA (1) knows the water availability of the current year, (2a) can sell water for a fixed price, and (2b) ask for a volumetric price, (3) can buyback water licenses, and (4) can perform on-site

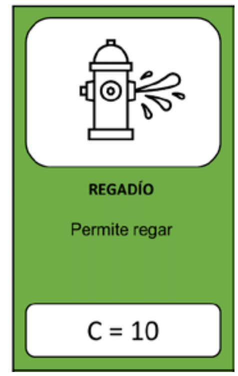
inspections at a cost per inspection or (5) can use satellite images to conduct inspections at a lower cost than individual inspection, but at a high sunk cost (WBA needs to purchase the remote sensing technology from the game master). NB the WBA does not decide on the allocation quantity - this is automatically done as = water available - environmental flows. Water availability is based on the results of the hydrologic modeling performed in the Cega lab, which is the model used by the WBA to allocate water.

- Game Master. Objective: none. Role: (1) sells irrigation and horticulture equipment to farmers, (2) sells remote sensing technology to WBA, (3) purchases the harvested crops, and (4) informs the WBA about water use at the end of each irrigation season.

Cards. The serious game 2 included the following cards (cost and profit are expressed in monetary units (MUs), while water in water units (WUs)):

Card	**Description**	**Cost**	
Land	It allows farmers to plant their crops	The Ministry of Agriculture fixes the cost	
Rainfed cereal	Low return Water requirement: 0 WU Expected profit: 3 MUs	Seed: 1 MU	

Card	Description	Cost	
Irrigated cereal	Medium return, irrigation equipment required. Water requirement: 3 WUs Expected profit: 8 MUs	Seed: 2 MUs	
Irrigated vegetables	High return, irrigation and horticulture equipment required. Water requirement: 10 WUs Expected profit: 30 MUs	Seed: 5 MUs	
Water license	It allows farmers to legally irrigate for the WUs purchased. Two cards were available depending on the WU's quantity: 1 and 5 WUs license	WBA fixes the cost	

Card	Description	Cost	
Irrigation equipment	It allows farmers to irrigate their crops	10 MUs	
Horticulture equipment	It allows farmers to plant irrigated vegetables	10 MUs	
On site inspection	It allows the WBA to ask farmers to show the crops they are growing and the licenses they own	20 MUs	

Card	Description	Cost	
Remote sensing technology	It allows the WBA to use satellite images to know what a farmer is growing - this information is provided by the Game Master	50 MUs	
Remote sensing inspection	It requires remote sensing technology. It allows the WBA to know what a farmer is growing and how much water is using.	2 MUs	

Table 15. Cards included in the serious game 2 of the Spanish lab.

Crop cards were designed to represent the actual conditions of the Cega lab. Their returns, costs, water use and yield variability (contingency cards) were designed based on observed data. The outcomes from policies adopted by players are based on simulations using the TALANOA modeling framework.

Contingency cards: each round, before selling their product to the game master, the farmers need to extract a contingency card that can modify their harvest. The contingency cards used in the serious game 2 are reported in Table 16.

Card	Description	Effect (on expected profit)	Number of cards	
Bad luck. Low prices	The demand of your crop falls, and you have to accept a lower price.	-25%	RC: 10 IC: 10 V: 10	
Bad luck. Pest	Pest halves production	-50%	RC: 10 IC: 10 V: 10	

Card	Description	Effect (on expected profit)	Number of cards	
Good luck. Productive seeds	Good seeds, you produce 1.5x more	+50%	RC: 10 IC: 10 V: 10	
Good luck. Higher price	Selling price rises.	+25%	RC: 10 IC: 10 V: 10	
Good job	You produce what you expect	0%	RC: 40 IC: 30 V: 10	

Card	Description	Effect (on expected profit)	Number of cards	
Bad luck. Bad quality of the seeds	The seeds you planted this year were not good, your production drops.	-75%	RC: 5 IC: 5 V: 0	
Bad luck. Frost	A late frost during growing season kills all your crop	-100%	RC: 3 IC: 3 V: 0	
Good luck. Specialized workforce	Your workers did a perfect job with total commitment and dedication, obtaining a significant increase in your production.	+75%	RC: 5 IC: 5 V: 0	

Card	Description	Effect (on expected profit)	Number of cards	
Good luck. Perfect weather conditions.	Good weather doubles your production.	+100%	RC: 5 IC: 5 V: 0	

Table 16. Contingency cards used in the serious game 2 of the Spanish lab. Legend: RC: rainfed cereal, IC: irrigated cereal, and V: irrigated vegetables.

Three rounds of the game were played during the second workshop. Uncertainty and surprise led stakeholders to ask for compensations through state aid or self-insurance mechanisms, which were nonetheless challenging to arrange in-game. Stakeholders suggested the inclusion of an insurance company as a player in the next version of the game. Another feedback from the stakeholders was the inclusion of a representative from the Water Police as a player in the game to implement sanctions more realistically for illegal water uses, which were observed consistently.

The replicability of the modeling framework and serious game elsewhere has been assessed in a series of meetings with the Spanish Ministry for the Ecological Transition and Demographic Challenge for the development of a Decision Support System model in the *Mar Menor* (Southern Spain), starting from 23rd of June 2022 (first meeting).