D2.1 [TALANOA Water] Data Sourcebook

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TALANOA

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Deliverable 2.1: Data Sourcebook VERSION 1.0

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4.0		*Forthcoming*

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☒ PU = Public, fully open, e.g. web

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

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

Executive summary

The data source book aims at gathering all the metadata needed in the labs for future modeling and baseline set up. This deliverable and metadata structure is derived from the D5.2 on Data Management Plan (DMP) and is therefore coherent with Talanoa Water's DMP. The aim of the DMP is that data in the project follows the principles of FAIR : Findability, Accessibility, Interoperability, and Reusability.

For each of the 6 water labs a summary of the principles of modeling is first presented to argue why the data collected is needed. Then metadata includes 20 variables that describes what, how and why the data has been collected and precise operational elements such as data openness.

In this first version, the priority has been given to metadata collection and structuring. Data sharing will follow in early 2022. The metadata and database must be seen as evolutionary throughout the project as both the science and the participation of TALANOA Water labs will be developed during the project and might identify the need for - or produce - new datasets.

Actualized versions of the metadata per lab are available at TALANOA_Sourcebook_Metadata - Google Sheets.

The data that are public and can be shared will be uploaded in Zenodo in the near future.

Content

1. Introduction : Objective of the Data Collection

The TALANOA Water project is structured in four thematic work packages WP1-4 (ENGAGE, DATA, MODELING, and LABORATORIES); this deliverable is the first in the WP2 DATA. It must be coherent with the D.5.2 Data Management Plan that sets operational characteristics and rules to manage, collect, store the data within TALANOA Water.

This deliverable objective is to gather and structure all the input metadata of the labs. This deliverable includes both a data sourcebook and a description of the data challenges and uses for each lab.

One of the important requirement is that the data produced follows the principles of FAIR : Findability, Accessibility, Interoperability, and Reusability. This is one of the main aims of the Data Management Plan.

The deliverable must also be understood as a state of the art in data identificiation, characterization and collection at the end of 2021 rather than a finalized version. If labs have already identified their main modeling strategy and consequent data needs, the process proposed by TALANOA Water which implies an important "field work" means continuous, or at least an extra year of, specification of objectives, of scenarios and strategies or processes to represent with models; and with each new or better (with participation) defined strategies or scenarios new data needs will emerge and will add to the present metadata sourcebook.

There are three main reasons for trying to harmonize the data :

- The objective to run the WAPOR accounting approach.
- The objective to have similar workflows and understanding of the modular approaches even if they are different in each lab.
- The objective to ease understanding of data in each lab for anyone in the project and above to encourage collaborations across labs and even after the project ends.

The collection and generation of data will inform and catalyze the objectives of TALANOA-WATER across its three pillars: Talanoa Water Dialogue, Actionable Socio-Hydrology Science, and Water Laboratories. By adopting transformational adaptation strategies to water scarcity under climate change, the project contributes to its IWRM (Integrated Water Resources Management) objectives of social equity, economic efficiency and environmental sustainability. Concepts from both pillars, the Talanoa Water Dialogue and Socio-Hydrology Science, will empirically feed into the outputs of all six pilot laboratories.

2. Input Data Characteristics

This deliverable is aimed at gathering **raw or harmonized data**. TALANOA-WATER will build on both freely accessible existing data and data with restricted access. This is why the metadata represents the core of the contribution of this deliverable. The database (data uploaded to the database) is the remaining. To organize the metadata across lab and project we characterize data according to 20 optional variables.

Categories in the metadata are presented on Table 1:

	Variable	***Short name of variable***	***value***	***comment***
Data summary	ID.	id.	[1; 2; 3...]	unique number
	Category	cat.	See below	
	Type of data	type		these are the cat given by Hadi (first table; generic names i.e. geologocal map)
	Data name	name		
Characteristics	Variables	variables		main variables of interest
	Data Provider	owner	Specific/Own elaboration	e.g. Water agency / own elaboration (Partner)
	Time Start	time start		"-" if no time related info (e.g. GIS)
	Time End	time end		"-" if no time related info (e.g. GIS)
	Time Step	time step		"-" if no time related info (e.g. GIS)
	location	location		e.g river basin
	spatial resolution	resolution		pixel, 8*8 km, municipality...
Method	Data Collection Method	method		Specify which method was used to produce the data including the instruments that have been used or other source data. To be filled if "own elaboration" is previously mentioned
Use	Data Use (WP,model)	use	e.g. hydrologic modul	Ideally specify the model, not only the WP. More than one is possible
Practical info	Open data	open	1/0	1=yes; 0=no If Open data = 1 then the data needs to be available on the data drive
	Data Use Restrictions	restrictions	text	If Open data = 0. This clearly states why this data is not open data, if any, (ex. Private source; governmental data; etc.).
	Collected	collected	1/0	This variable is to know whether the lab has already received/collected the data. This is to help monitor and guide the labs work.
	Data sharing	uploaded	1/0	
	Link to the data	link		(URL)
	Data Format	format	e.g tiff, shp., csv.	

	Expected Data Size	size		optional

Table 1 – Metadata characterization in the TALANOA Water project

The category of data are:

(i) CLIMATE : climate data

(ii) HYDRO : hydro(geo)logic including dams related data

(iii) LAND USE : land use & agronomic data, that will help characterize the water uptake

(iv) ECON : economic datasets (micro & macroeconomics)

(v) GIS : GIS data

(vi) OTHER : Other data, that might be specific to each lab and required according the models or processes that will be represented

The remaining of the deliverable is the metadata for each lab. Actualized versions of this metadata are available at TALANOA_Sourcebook_Metadata - Google Sheets.

3. Generic data & modeling

Two modeling approaches are at a higher scale than the labs :

- The WAPOR accounting approach
- The macro-economic modeling approach

a. WAPOR data

To perform the rapid water accounting plus (WA+) modeling approach, designed by IHE Delft with its partners FAO and IWMI, the FAO WaPOR database (WaPOR v2.0), along with other open-access global databases, will be utilized. In places where WaPOR data is not available (i.e. Europe), the Lebanese Lab can provide the ET data for water accounting using the HSEB model (Jaafar et.al, 2022, forthcoming). Work on the WaPOR database will include deriving remote sensing data, preparing the data for computations of monthly water balance for WA+ purposes, and performing quality checks such as comparing WaPOR precipitation data with in situ observations, as well as Actual Evapotranspiration (Eta) with other remotely sensed Eta estimates.

The FAO WaPOR database (2009-2021) is publicly accessible and uses satellite data that allows the monitoring of agricultural water productivity at different scales and available for Africa and Near East.

For the purpose of running the WA+ tool, data derived from WaPOR will incorporate: monthly actual evapotranspiration and interception, dekadal interception, monthly reference evapotranspiration, daily and monthly precipitation, as well as yearly land cover classification.

The WA+ modeling approach will also include global data derived from several databases such as monthly total water storage change (GRACE- Gravity Recovery and Climate Experiment – NASA mission), global reservoirs (GRaND- Global Reservoir and Dam Database – GDW-Global Dam Watch), topsoil saturated water content (HiHydroSoils), monthly observed flows (GRDC-Global Runoff Data Center), and Terrestrial and Marine Protected Areas (WDPA-World Database on Protected Areas).

b. The macro-economic modeling approach

The macro-economic model is calibrated on a regionalized version of the GTAP 8.1 database (Narayanan et al., 2012), which is a collection of Social Accounting Matrices (SAMs) for 57 economic sectors and 134 countries or groups of countries in the world for the base year 2007. The EU regional detail has been extended considering 138 territorial units. Starting from the national SAMs of the European Union available in the GTAP data, we use sub-national information from Eurostat (Economic Accounts for Agriculture, 2018; Structural Business Statistics, 2018; Gross value added at basic prices by NUTS 3 regions, 2018) to get a regionalized database at the NUTS2-1 level. For the fishery sector we use information from the Regional Dependency on Fisheries report (EU, 2007) and for forestry data from the Global Forest model (Di Fulvio et al., 2016).

Sub-national domestic demand and trade with other regions within the country are computed using the so-called Simple Locations Quotients (SLQs) (Bonfiglio, 2008, Bonfiglio and Chelli, 2008, Miller and Blair, 2009). SLQs provide a measure of the sectoral specialization in the regional economy and starting from this it is possible to determine the domestic demand and aggregate demand for imports. Then a gravitational approach in line with Horridge and Wittwer (2010) is implemented to estimate the bilateral trade flows across sub-national regions. An exhaustive description of the methodology can be found in Bosello and Standardi (2018).

In the macro model a special focus is dedicated to the European Mediterranean countries (Spain, France, Italy and Portugal) which are all dis-aggregated at the NUTS-2 sub-national level, the maximum geographical detail in the macro-economic model. Tunisia and Egypt have only national detail. Lebanon will need additional work because in the GTAP database it is inside a broader region called "rest of Western Asia" which includes also Iraq, Jordan, Palestinian Territory, Syria and Yemen.Egyptian Water Lab.

4. Egyptian Water Lab.

a. Presentation of the modeling ambition in the lab

The Egyptian Lab. ativities will focus on the Nile Delta region. The cultivated area of the Nile Delta is 4.35 million feddan (1 feddan equals 4,200 m^2 or 0.42 ha), 93% of which are old dark lands of alluvial soils that have a texture which ranges from heavy clayey to clay. This area represents 71.6% of the total old alluvial land in Egypt (6 million feddan) and 55.5% of the total officially cultivated lands (8.6 million feddan). The Nile Delta has recently been suffering from a sharp decline in the area of fertile agricultural land, which is difficult to compensate as a result of salinity, water logging, and seawater intrusion in addition to pollution, nutrient depletion, and population encroachment by builing and other uses, and this degradation is subject to increase as a result of reducing the areas planted by rice (Abu-Zeid 1988, FAO 1992). In addition, soil salinity is caused by excessive accumulation of salts and is typically pronounced at the soil surface. Saline soil distribution is closely related to environmental factors such as climatic, geological, geochemical and hydrological conditions. Poor soil and water management, the intrusion of seawater, the use of slightly saline water (drainage or mixed water) for irrigation without proper management and agronomic practices, or the use of saline groundwater as the only source for irrigation are presently the main causes of salinization in Egypt (AbouKheira, 2005). The majority of salt-affected soils in Egypt are located in the northern-central part of the Nile Delta and in its eastern and western sides. Other affected areas include Wadi-El-Natroun, Tal El-Kebeer, the oases, many parts of the Nile Delta and Valley, and Fayoum province. Approximately, 0.9 million ha suffer from salinization problems in cultivated areas. Furthermore, 60 % of cultivated lands in northern Delta, 20% of the southern Delta and Middle Egypt, and 25% of the Upper Egypt regions are all salt-affected. Salinity of irrigation water can cause a build-up of salts in the root zone, particularly if the internal drainage of soils (or leaching), either due to rainfall or by applied irrigation, is inadequate. Proper irrigation management can avoid salt accumulation by providing adequate drainage to leach added salts from the affected soil root zone layers. High levels of soil salinity can be tolerated if salt-tolerant plants are grown (FAO 1992).

Technical feasibility of saline agriculture in Egypt (Moen, et. al., 2013, Heijden, et. al., 2014) needs to be established at two levels: conceptual and practical. At the conceptual level, simulation and demonstration models can establish the optimum spatial scales for the range of crops and application systems. This will account for the spatial limitations of the application system, the constraints imposed by sensing needs and capability, and the ability of simulation tools to accurately predict soil moisture, yield and total dry biomass of crops in salty soils. This stage must also determine if the diagnostic tools needed to determine the causes of particular crop responses are available and sufficiently accurate. On a practical level, the feasibility of crops & practices should be proven and demonstrated in field trials with specific on-farm irrigation water management component. These could account for and discuss with the other non technical constraints of famers or companies running agriculture. Indeed other constraints such as capital or human resources and know how are important to consider agricultural development. Accordingly, the databases will be used to depict salinity-affected lands and post-classification operations in GIS and RS (remote sensing) to develop maps for distributing saline water and lands affected by salinity, as well as optimum cropping pattern in the Nile Delta.

1. **Mapping water quality and salt affected lands:**

Satellite Technologies (GIS & Remote sensing) are a convenient mean for decision support systems. Digital-image processing is acquired by GIS & RS for brackish/saline materials (water and soils) demarcation for the location of "Optimum cropping pattern" for salt-affected lands and saline water. Improved mapping through remote sensing of highly reflective saline soil helps us for taking mitigation measures. Qualitative and quantitative salinity modelling is now possible due to the optical radar data. Thus various approaches like Aster Salinity Index (ASI for Agriculture), Normalized Difference Salinity Index (NDSI), Soil Adjusted Vegetation Index (SAVI), Brightness Index (BI), Salinity Index (SI) and Soil Salinity & Sodicity Index (SSSI) have been used to develop the optical data (multi spectral) from Enhanced Thematic Mapper i.e. LANDSAT ETM + using GIS and remote sensing.

Objectives:

- Optimum cropping pattern by using Geographic Information System and Remote sensing & socio-economic constraints;
- Mapping water quality & salt affected lands; and

Methodology:

"Model Farm" will be established at least at four test sites in four different command areas in order to achieve our proposed goal and objectives. These pilot areas are chosen, because they represent hotspots of soil and water salinity of the Nile Delta.

Soil sampling:

Bouaziz et al. (2011) method will be used for soil sample collection. Global positioning system (GPS) will be used for the exact coordinates for each composite soil sampling at the proposed test site. Secondary data from the published water quality reports, soil survey reports, soil atlas and maps for the project areas will be collected and used during interpretation.

Project area base map:

We will use the databases to portray the salt affected lands and post-classification processes in GIS & RS to develop project base map.

Satellite data processing:

LANDSAT ETM+ satellite images of high spatial resolution will be acquired for the test sites. The downloaded images will be geo-fixed to the UTM (Universal Transverse Mercator) coordinating system by the World Geodetic System — 1984 (WGS-84). We will use the Enhanced Visualization Imaging i.e. ENVI software to standardize and process all the remote sensing data.

2. Land suitability and capability

The Agriculture Land Evaluation System for arid and semi-arid regions (ALES-Arid) (Ismail et al., 2005) was developed as a software1 to estimate the agriculture land evaluation linked directly to its relational database and indirectly with a GIS through a loosely coupled strategy. The ALESarid-GIS software is used for evaluating land suitability and capability for producing different crops based on physical and chemical properties of soil, in addition to irrigation water quality. ALES-Arid was redeveloped as a dynamic link library (.dll) integrated with a GIS through the embedded coupling strategy on a common GIS user interface (ArcGIS desktop) entitled ALESarid-GIS as a GIS-based multicriteria decision analysis (GIS-MCDA) in order to assess the agricultural land capability and suitability for 28 activities (field crops, vegetable crops, forage crops and fruit trees). In addition, wheat and maize yield prediction (Abd El-Kawy et al., 2010), The evaluation is based on crop suitability affected by the environmental potentially at the site, such as the physical, chemical and fertility characteristics of the soil, irrigation water quality, and climatic conditions that represent the main factors affecting agricultural soil suitability and productivity in arid and semi-arid regions. Input data consists of soil physical properties, soil chemical properties, soil fertility properties, and finally climate data. ALESarid-GIS was designed to assess land suitability and capability for producing different crops based on both decision trees and maximum limitation tables.

The model retrieved the structured input data from the relational database and then temporally stored. Input data consist of:

- Soil physical properties (soil texture, soil depth, available water, and soil permeability);
- Soil chemical properties (soil salinity, soil alkalinity, calcium carbonate content, gypsum content, cation exchange capacity, and soil reaction);
- Soil fertility properties (organic matter, available forms of N, P, and K);
- Irrigation water characteristics and qualities (water salinity and toxicity); and
- Climatic data present & future (means summer and winter temperature).

3. Irrigation management and crop production in salinity prone areas of the Nile Delta

SALTMED model is a generic model that can be used for a variety of irrigation systems, soil types, crops and trees, water application strategies and different water qualities. The early version was successfully tested against field experimental data. The current version, SALTMED 2015, includes additional sub-

[1] work on Windows operating system

models, crop growth according to heat units/degree days, crop rotations, nitrogen dynamics, soil temperature, dry matter and yield, subsurface irrigation, deficit irrigation including the Partial Root Drying, PRD, drainage flow to tile or open drains systems, presence of shallow groundwater, evapotranspiration (ET) using Penman–Monteith equation, with different options to obtain the canopy conductance. The current version allows up to 20 fields or treatments to run simultaneously (Ragab et. al., 2016).

The data inputs needed to run these models is described in the metadata file.

b. Metadata

Metadata for the egyptian lab are still under characterization and can be seen here: [TALANOA_Sourcebook_Metadata - Google Sheets]

One of the specifity is that the majority of data is not open access and will not be uploaded because of data sharing restrictions resulted from the political situation arised due to the dilemma of the Ethiopian Dam.

Table 1. HEAC metadatabase for the Egyptian Lab

c. Perspectives in terms of data collection, validation and data gaps

The collection of the data have started since the beginning of the project concerning physical & chemical soil properties. We plan to receive the first dataset by May – June 2022. Concerning economic data, we still do not know how the economic model will be designed and will collect the data when this will be fixed (April 2022).

d. References:

Abd El-Kawy, O. R.; H. A. Ismail; J. K. Rod and A. S. Suliman. 2010. A developed GIS-based land evaluation model for agricultural land suitability assessments in arid and semi-arid regions. Research Journal of Agriculture and Biological Sciences, 6(5): 589-599.

Aboukheira, A. A. 2005. A study of trickle irrigation systems for irrigating some horticultural crops in Delta soils. Ph.D. thesis. Shebin El-Kom, Minufiya University, Egypt.

Abu-Zeid M. 1988. Egypt's policies to use low-quality water for irrilzation. Proc. Symp. Re-use of Low-quality Water for Irrigaticn. Water Research Centre, Cairo.

Bouaziz, M.; Gloaguena, R.; Samirb, B. 2011. Remote mapping of susceptible areas to soil salinity, based on hyperspectral data and geochemical, in the Southern Part of Tunisia. Proc. SPIE 2011, 8174, doi:10.1117/12.898199. 3.

Food and Agriculture Organization. 1992. The use of saline waters for crop production. Tech. Rep., Food and Agriculture Organization, Rome, Italy, 1992.

Heijden, P. G. M., K. Roest, F. Farrag, H. ElWageih and Sadek, S. 2014. Integrated Agri-Aquaculture with brackish waters in Egypt; Mission Report (March 9 – March 17, 2014). Wageningen, Alterra Wageningen UR (University & Research centre), Alterra report 2526. 52 pp.; 3 fig.; 2 photos; 1 tab.; 5 ref.

Ismail, H. A., Bahnassy, M. H. & Abd El-Kawy, O. R. 2005. Integrating GIS and modeling for agricultural land suitability evaluation at East Wadi El-Natrun, Egypt. Egyptian Journal of Soil Science, 45, 297-322.

Moen, H., K. Roest & Kamstra, A. 2013. Feasibility of the Use of Brackish Groundwater in Integrated Aqua-Agriculture systems in Egypt. Study Report by Dienst Landelijk Gebied, ALTERA, Wageningen UR and IMARES, Wageningen UR. 46 pp plus annexes.

Ragab, R., Choukr-Allah, R., Nghira, A. & Hirich, A. 2016. SALTMED Model and Its Application on Field Crops, Different Water and Field Management and Under Current and Future Climate Change. In: Choukr Allah, R., Ragab, R., Bouchaou, L., Barceló, D. (eds.) The Souss-Massa River Basin, Morocco. The Handbook of Environmental Chemistry. Springer: Berlin, pp. 1-48, doi:10.1007/698_2016_74.

5. Italy – Po River basin

a. Presentation of the modeling ambition in the lab

The Italian Lab is the Italian Po river basin located in the Emilia Romagna region. To explore alternative & transformative adaptation strategies to water management we develop the following modeling architecture.

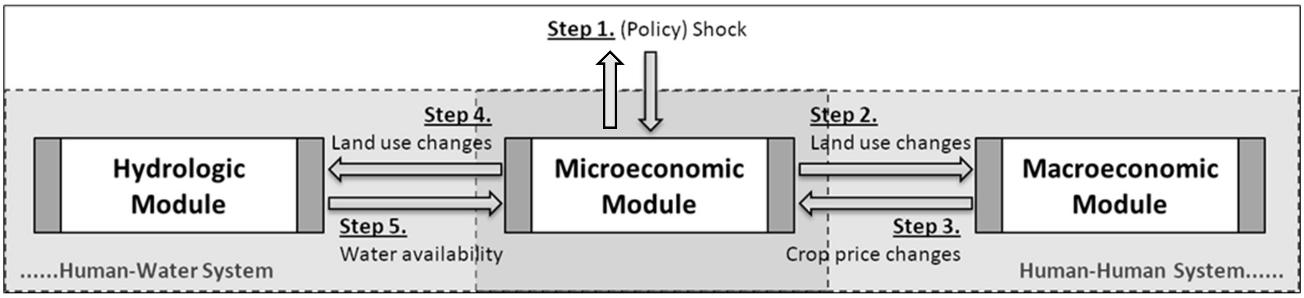

Figure 1 . Schematic representation of the five protocol connections that define the methodological steps to iteratively couple the micro, macro and hydro modules.

The coupling framework depicted in Figure 1 is designed to be replicable and flexible, capable of including alternative micro-, macro-economic and hydrologic models. The coupling framework can be integrated with standard agricultural microeconomic models including Expected Utility (von Neumann and Morgenstern, 1953), Linear Programming (Paris, 2015), Positive Mathematical Programming (Howitt, 1995), Multi-criteria Decision Models (Pereira et al., 2003; Sumpsi et al., 1997) and Positive Multi-Attribute Utility Programming models (Essenfelder et al., 2018; Gutiérrez-Martín and Gómez, 2011). Macroeconomic standard models that can be incorporated into the coupling framework include Computable General Equilibrium (CGE) (Hertel and Liu, 2016) and Input Output (IO) models (Oosterhaven and Bouwmeester, 2016). Ideally, macroeconomic models should be regionally-calibrated (NUTS 2 scale or similar) to increase the spatial disaggregation of the shares of value added, and accordingly of labor, capital, natural resources and land, and the accuracy of the coupling with microeconomic models (Carrera et al., 2015; Koks et al., 2015). Finally, a large pool of hydrologic models is available in the literature, but not all of them can be integrated into the coupling framework above. In the Italian Lab the choice has not already been made. To be compatible with economic models in the modeling framework proposed in this paper, hydrologic models must meet the following criteria: i) be spatially distributed (i.e. fully or semi-distributed models, to be capable of spatially representing different microeconomic agents); and ii) have a land management module (i.e. be capable of translating the crop portfolio choices taken by the different microeconomic agents into hydrological responses). A non-exhaustive list of models satisfying these criteria includes: the Soil and Water Assessment Tool – SWAT (Arnold et al., 1998); Annualized Agricultural Non-Point Source Pollution Model – AnnAGNPS (Young et al., 1989); Areal Nonpoint Source Watershed Environment Response Simulation – ANSWERS 2000 (Bouraoui and Dillaha, 2000); Agricultural Policy / Environmental eXtender Model – APEX (Gassman et al., 2009); US Army Corps of Engineers - Hydrologic Engineering Center - Hydrologic Modeling System – HEC-HMS (US Army Corps of Engineers, 2015); Soil and Water Integrated Model – SWIM (Krysanova et al., 2005).

b. Metadata

cat.	type	name	owner	time Start	time End	time step	location	resolution	method	use	open	restrictions	format
HYDRO	MODFLOW files	Emiro	ARPAE-Regione Emilia-Romagna	2003	2014	monthly	Emilia-Romagna	1 km	Spatial interpolation of geologicla cross sections		1		ASCII
HYDRO	Geologic map	Carta geologica, 1:25.000	Regione Emilia-Romagna				Emilia-Romagna	1:10000/1:25000	Ortofoto		1		shp
HYDRO	List of spring locations and elevations	DBTR - Sorgent	Regione Emilia-Romagna				Emilia-Romagna	1:10000			1		shp
HYDRO	Spring discharges		Multututility Companies				Emilia-Romagna	1:10000	Gauge		0	Upon request	xls/csv
HYDRO	Groundwater levels in monitoring wells	Monitoraggio acque sotterrane	ARPAE	2013	2021	Two times per year	Emilia-Romagna		Observation		1		xls/csv
HYDRO	Locations of monitoring wells	Monitoraggio acque sotterrane	ARPAE	2013	2021		Emilia-Romagna		Observation		1		xls
HYDRO	Pumped volume - public wells		Multiutility Companies				Emilia-Romagna	1:10000	Gauge		0	Upon request	xls/csv
HYDRO	Pumped volume - private wells		Regional Agencies /Regions/Provinces				AdBpo	1:10000	Gauge		1	Upon request	xls/csv
HYDRO	Stream flows		Regional Agencies	'90	2021	Daily	AdBpo		Gauge		1		xls/csv
HYDRO	Inter-basin transfers		Regional Agencies /Irrigation Consortia/Dam owners				AdBpo				0	Upon request	xls/csv
HYDRO	Discharge		Regional Agencies	'90	2021	Daily	AdBpo		Gauge		1		xls/csv
HYDRO	Hydropower production		GSE	2016	2019	yearly	National	Regional			1		xls
HYDRO	Dam storage volume	Cartografia delle grandi dighe	Ministero Infrastrutture e Trasporti				National	1:10000	national registry dataset		1		webgis
CLIMATE	Precipitation	ERG5	ARPAE	2001	2021	Hourly-Daily	Emilia-Romagna	5 km	Spatial interpolation on a regular grid of observation from historical stations		1		GRIB
CLIMATE	Temperature - Daily max	ERG5	ARPAE	2001	2021	Hourly-Daily	Emilia-Romagna	5 km	Spatial interpolation on a regular grid of observation from historical stations		1		GRIB
CLIMATE	Temperature - Daily min	ERG5	ARPAE	2001	2021	Hourly-Daily	Emilia-Romagna	5 km	Spatial interpolation on a regular grid of observation from historical stations		1		GRIB
CLIMATE	Evapotranspiration	ERG5	ARPAE	2001	2021	Hourly-Daily	Emilia-Romagna	5 km	Spatial interpolation on a regular grid of observation from historical stations		1		GRIB
CLIMATE	Relative humidity	ERG5	ARPAE	2001	2021	Hourly-Daily	Emilia-Romagna	5 km	Spatial interpolation on a regular grid of observation from historical stations		1		GRIB
CLIMATE	Wind speed	ERG5	ARPAE	2001	2021	Hourly-Daily	Emilia-Romagna	5 km	Spatial interpolation on a regular grid of observation from historical stations		1		GRIB
CLIMATE	Solar radiation	ERG5	ARPAE	2001	2021	Hourly-Daily	Emilia-Romagna	5 km	Spatial interpolation on a regular grid of observation from historical stations		1		GRIB
LAND USE	Crop-type map	I-colt	ARPAE	2008	2021	Yearly	Emilia-Romagna		Remote Sensing (NDVI)		1		shp
LAND USE	Mean crop yield statistics		Regione Emilia Romagna/ISTAT	2006	2021	Yearly	Italy		Surveys/estimations		1		csv/pdf
LAND USE	Soil map	Carta dei suoli_regione Emilia Romagna	Regione Emilia-Romagna	2018	2018		Emilia-Romagna	1:50000					shp
LAND USE	DEM	DTM	Regione Emilia Romagna	2015	2015		Emilia-Romagna	5 m	Lidar		1		tiff
LAND USE	Land use class map		Uso del suolo_regione Emilia Romagna	2017	2017		Emilia-Romagna	1:10000	Ortofoto		1		shp
LAND USE	Land use class map	Corine Land Cover	EEA	2018	2018		Europe	100 m/25 ha	Remote Sensing		1		tiff/shp
LAND USE	Land use classes table	Corine Land Cover	EEA	2018	2018		Europe	100 m/25 ha	Remote Sensing		1		tiif/shp
OTHER	Location of wastewater plants		ARPAE	2018	2018		Emilia-Romagna				1		shp
OTHER	Wastewater plant discharge		Regional Agencies /Regions/Provinces				AdbPo		Estimation		0	Upon request	xls/csv
OTHER	Other point source pollution discharges		Regional Agencies /Regions/Provinces				AdbPo		Estimation		0	Upon request	xls/csv
OTHER	Locations of point source pollution		Regional Agencies /Regions/Provinces				AdbPo		Estimation		0	Upon request	xls/csv
OTHER	Water quality parameters Surface	Rete di monitoraggio delle acque fluviali	ARPAE	2010	2021	Monthly	Emilia-Romagna		Observation		1		xls/csv
OTHER	Localization of monitoring station	Rete di monitoraggio delle acque fluviali	ARPAE	2010	2021						1		shp
OTHER	Water quality parameters GW	Monitoraggio acque sotterrane	ARPAE	2013	2021		Emilia-Romagna		Observation		1		xls/csv
OTHER	Localization of energy production plants	Impianti	ARPAE	2018	2018		Emilia-Romagna						xls/csv
OTHER	Energy used per sector	BER	ARPAE	2014	2018	Yearly	Emilia-Romagna	Municipality					xls/csv
HYDRO	Water abstractions/uses per sector		Regional Agencies /Regions/Provinces				AdbPo		Estimation		0	Upon request	xls/csv
ECONOMIC	Microeconomic inputs		RICA	2008	2016	Yearly	Emilia-Romagna	Irrigation district			1		xls/csv

Table 1. HEAC metadatabase for the Italian Lab

c. Perspectives in terms of data collection, validation and data gaps

For macro-economic data see section on Global data.

Environmental data

Concerning the required environmental data to feed hydrological models the Italian lab can rely on substantial regional databases that ranges from hydrology (water availability and uses, quality) for surface and ground water, to meteorological and GIS layers data, with particular emphasis on Emilia Romagna Regional datasets, that include also outputs from numerical models such as groundwater model.

Such data shall be used to validate-calibrate selected hydrological models locally; over 60% of data can be retrieved through direct access to Regional web portals, while for the remaining ones a request shall be made to the data owners.

Better Availability is for core data necessary for hydrological modeling validation such as Terrain, land/soil/geology, hydrometeorological gauging stations(surface and ground water), while groundwater modeling inputs/outputs shall be requested directly to the Agency (or Regional office) that set up the model.

Difficulties and slow response times are envisaged in collecting more granular information's on water quality, point discharges and withdrawals /diversions from permitting authorities and main users (that feed surface water balance schemes and support evaluations over expected environmental effects of discharges regimes); support form Regional or District Authority that may have already summarized such data (i.e. for water management masterplans) shall be requested to try and speed up missing data collection. A reasonable estimation for the collection of non-downloadable data is mid 2022.

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6. France

a. Presentation of the modeling ambition in the lab

The French water Lab is the Aude river basin. The work will concentrate on the lower and medium Aude where the water deficit between uptake and resource is concentrated (and the large majority of uptakes).

While the detailed modeling will be determined with stakeholders and elaborated during the bilateral exchanges and in the science policy workshops, the general idea of modeling is presented in Figure 2. This figure also presents the articulation with the participation in the lab. The core of the modeling architecture will be formed by the agro-economic model and the hydrological model that will be coupled thanks to a platform such as, e.g., Openfluid (Fabre et al. 2010). There is still uncertainty on how the crop growth (agronomic processes) will be represented and if will be integrated into the economic model. The opportunity to resort to a macroeconomic model (see e.g. Figure 4 in the Spanish lab) is also still to be studied and contemplated with the Italian partners (CMCC) that master macroeconomic modeling. The microeconomic model will be an agricultural economic programming model (e.g. Graveline, 2016) developed with GAMS software. The challenge for the economic modeling will be to integrate disruptive innovations whereas this type of modeling is known to be appropriated to handle marginal changes (increases in prices of outputs or inputs). This challenge will be dealt with a PhD dedicated to it. The hydrological model will be developed with the open source airGRiwrm approach (Dorchies et al. 2020).

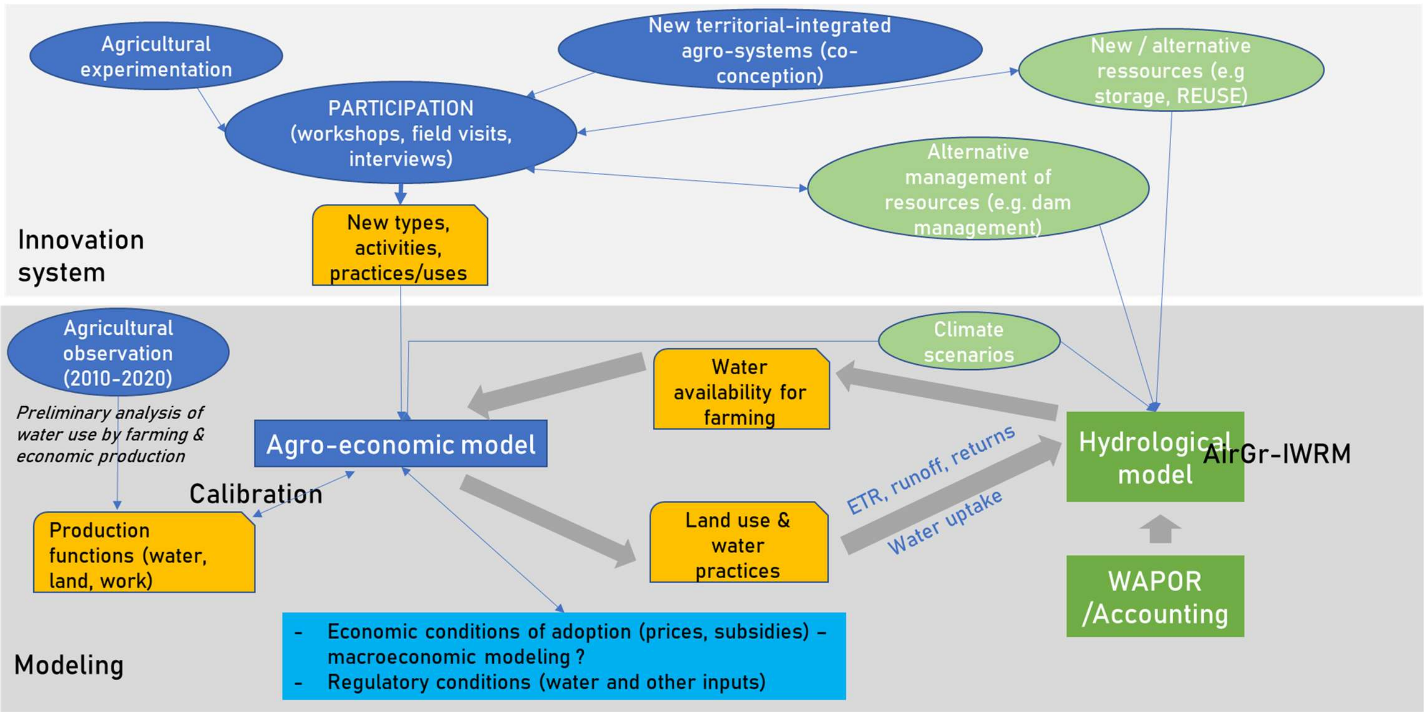

Figure 2 Preliminary vision of modeling for the French water lab & Articulation between modeling & participation

b. Metadata

Metadata for the French lab are still under characterization and can be seen here:

TALANOA_Sourcebook_Metadata - Google Sheets

One of the specificity is that the majority of data is not open access and will not be uploaded because of data sharing restrictions. INRAE has nevertheless obtained the right either with specific agreements (AERMC / uptake data) or long-term contracts (Météo France/climate data, BRL/networks) to use and exploit the data mentioned in the metadata.

c. Perspectives in terms of data collection, validation, and data gaps

Data collection will be completed in early 2022. Some of the data such as agricultural water use needs to be produced by the TALANOA team resorting to GIS, uptake, census, and field validation data. The agricultural census of 2020 (existing every 10 years) has just been released and individual data will be available for treatment from April 2022 on.

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7. Lebanon

a. Presentation of the modeling ambition in the lab

The study area is the Litani Basin. The Litani River rises in the Beqaa Valley of Lebanon at an altitude of 850m, where agriculture is the largest water consumer, and empties into the Mediterranean Sea north of Tyre. The river is witnessing water stress and is affected by urgent water quality and quantity problems, threatening populations over its 170 km stretch. The catchment area is about 2,176 square kilometers, equal to 20% of the country's total area. The leading causes of increased water use are population growth, conflicting water uses, over-exploitation of groundwater resources, and water pollution. Impacts from climate change are just the final straw to break the camel's back.

Figures from 2009 to 2016 show that water availability in the Basin is only 800 cubic meters per capita per year. The groundwater resources are depleted by around 57.5 million cubic meters per year, and water storage is decreasing to about 50 million cubic meters per year. Most of the domestic and industrial water in the Basin is left untreated, with high levels of pollution resulting in non-recoverable water of about 469.5 million cubic meters per year, threatening public health and ecosystem functions.

Objectives:

We aim to assess the water resources situation in the Litani Basin from 2017 to 2020. Sustainable utilization of the Litani River water resources is critical and requires getting further insights on water availability, withdrawals, consumptive and non-consumptive uses, and the resulting services and benefits. For this purpose, we will run the rapid Water Accounting plus system (WA+), designed by IHE Delft with its partners FAO and IWMI using remote sensing derived data from FAO's WaPOR database (WaPOR v2.0) along with other open-access databases. The WA+ framework is essentially required to complement the lack of routine water resources data collection while incorporating spatially distributed water consumption. Remarkably, our analysis will perform a basin-wide analysis (WA+ Resource Base) and further investigate the following:

- Assess the current water resources availability and utilization status in the Litani Basin
- Track surface and groundwater fluxes
- Assess inflows and outflows
- Map net water generation and expenditure
- Reflect on the quality of the WaPOR v2.0 data for WA+

Model scheme:

The WA+ methodology is based on the early work of Molden (1997), and is further developed by Karimi (2014) and Bastiaanssen (2015). We use the models and scripts that are created to calculate the water accounts available in GitHub under the water accounting account[2]. The Rapid water accounting tool available in GitHub only provides the resource base sheet, which is the major output of water accounting+. It is mainly used when we are interested in rapidly assessing the water resource situation in a basin or when all data needed to complete WA+ might not be available. The approach distinguishes green evapotranspiration (from rainfall) and incremental evapotranspiration (groundwater or water supplied through irrigation). It also distinguishes ET (both rainfall and incremental) per land-use class. In addition, WA+ tracks surface and groundwater fluxes and assesses inflows and outflows. The WA+ framework will

[2] https://github.com/wateraccounting

act as a reporting mechanism for water fluxes, flows, and stocks, that are summarized by means of the WA+ sheet. The assessment holds a potential contribution to better understanding the possible reprecussions of water productivity increases on water users, and provides an enabling environment for exploring the role of land use and land cover on consuming and producing water.

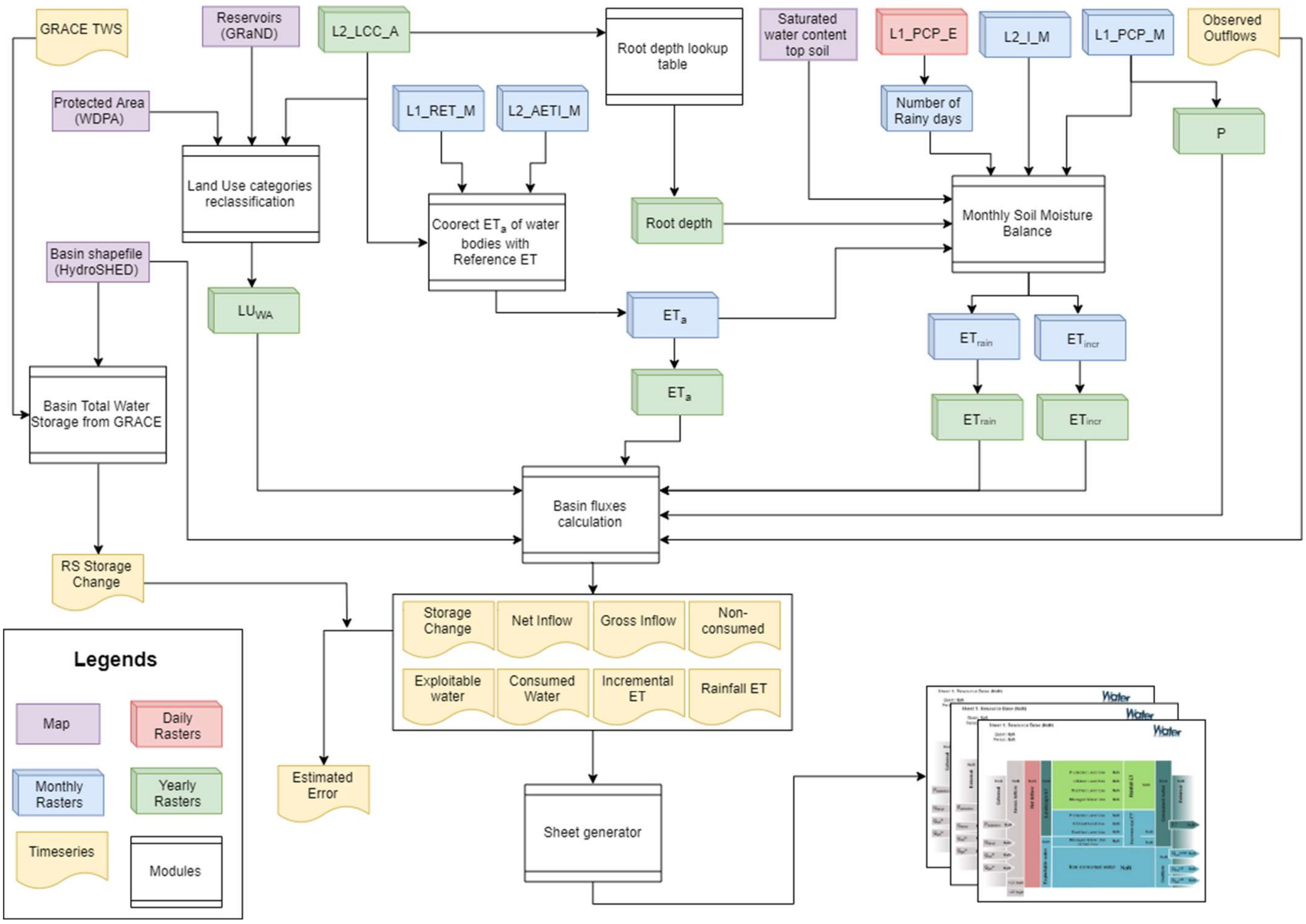

Figure 3 Flow chart of the water accounting process and the data used to develop the water accounting for Litani River Basin

b. Metadata

The first step needed to complete WA+ is collecting the required data. The required data can be classified into remotely sensed spatial data and the time-series data of ground observations. The remotely sensed data includes data on catchment boundary, land use, precipitation, ET, change in storage, protected areas, and reservoirs. Timeseries data such as flow measurements. Basin boundary can be obtained from HydroSHEDS, local authorities or can be delineated from digital elevation models (DEM). In WA+, theland-use map divides the basin into four major categories which are protected (areas with a nature status), utilized (areas with minimal human influence), modified land use (areas that have been modified), and managed water use (areas where water flow is controlled by humans). Data on protected areas can be retrieved from the World Database on Protected Areas. Data on reservoirs can be retrieved from Global Reservoir and Dam (GranD). More details on the data requirements are shown in the link provided below.

TALANOA-Sourcebook Metadata Sheet-Lebanese Lab

c. Perspectives in terms of data collection, validation, and data gaps

The required data will be collected for the recent years (2017-2020). However, before using the data for the Water Accounting Plus, several quality checks will be performed including:

- comparing WaPOR precipitation data with in situ observations
- comparing WaPOR ETa (Evapotranspiration) with other remotely sensed ETa estimates
- assessing the difference between WaPOR-derived basin-scale water balance and total water storage from GRACE, the Gravity Recovery and Climate Experiment NASA mission that studies key changes in the planet's waters, ice sheets, and the solid Earth.

Economic Data

The Lebanese water lab has already collected most of the data needed for running the models since the beginning of the project. Economic data may be utilized in the socio-economic model that will be designed and developed by TALANOA consortium partners. The lab will potentially contribute to informing the transformational strategies of TALANOA-WATER by utilizing the economic data, along with the WA+ tool, to explore single or multiple socio-economic scenarios (e.g. policy scenario or climate change scenario). We aim to run micro-models that will expedite the assessment of the responses of users, as well as allow the evaluation of the possible socio-economic reprecussions of alternative transformational policies.

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8. Spain

a. Presentation of the modeling ambition in the lab

Recent advances in the construction of protocol-based modular frameworks provide the backbone for the development of interdisciplinary modeling hierarchies that connect multiple systems through two-way feedbacks (*multi-system hierarchy*). Each module within the hierarchy can be populated with multiple models (*multi-model ensemble*) and combined with scenario discovery techniques that explore scenario uncertainty through varying initial states and forcings (e.g., climate change scenarios, policy scenarios) (CMIP6, 2021; ISIMIP, 2021). The result is a large database of simulations in which each simulation represents the economic and environmental performance under one specific scenario and modeling setting. This information can be used to identify futures where proposed policies meet or miss their objectives, explore potential tipping points, and inform the development of robust policies that show a satisfactory performance under most conceivable futures (Marchau et al., 2019).

Below we provide an illustrative example of the protocol-based modular hierarchy that will be adopted in the Cega Water Lab (Figure 1). In this basin, policymakers and other relevant stakeholders are mostly concerned about the impacts of water conservation policies on agriculture, and the tradeoffs that emerge between environmental and economic impacts. Since the policy target is restore and conserving water bodies, a hydrological model will be necessary to empirically assess the repercussions of the policy on them. Also a microeconomic model will be necessary, since theoretical and empirical evidence shows that farmer's beliefs and perception of water scarcity is a key factor determining adaptive responses in human-water systems, which in turn condition water use and other physical (e.g., land use) and economic impacts (Alam, 2015; Udmale et al., 2014). If changes are marginal or happen at a small scale, we can assume that input (e.g., labor, machinery) and output prices will not be affected by the policy ("small open economy" assumption) (Schöb, 1998). However, large-scale shifts in the crop portfolio, e.g., as a result of a region- or nation-wide policy, can lead to impacts on prices through feedbacks into the output of economic sectors at a regional and supra-regional scale (Hertel and Liu, 2016). As the economy transitions towards a new equilibrium, inputs and commodity prices, including those relevant for agriculture, will change, affecting in turn farmers' decisions. This calls for a macroeconomic model. Although the Cega is a relatively minor basin within the Douro River Basin and the Castile and León Region, it concentrates much of the horticultural production of the region, and thus any local policy can affect regional and even national markets. Thus, a macroeconomic module will be included as well.

The hierarchy will work as follows: initial states and forcings (scenarios), defined by unique combinations of a policy/policy mix (as per those agreed with stakeholders, a preliminary description of which is available in the Grant Agreement) that will force microeconomic models to assess users' responses. Resulting impacts on land use, income, and/or utility (monetized, e.g., through compensating variation) are adapted and imported into a macroeconomic modeling framework to calculate the economy-wide repercussions of the policy shock across sectors and regions (Carrera et al., 2015). Macroeconomic models can feedback into microeconomic models, e.g., through price changes as predicted in Computable General Equilibrium models (Hasegawa et al., 2016; Ronneberger et al., 2009). Under a time-invariant setting (setting 1), this iterative process can be repeated until convergence is reached, at which point predictions are stable and consistent, and comparative statics are performed. Convergence can be assessed through a convergence test (Hasegawa et al., 2016; Ronneberger et al., 2009). Physical outputs (e.g., land use, water withdrawals, water consumption) resulting from micro- and macro-economic simulations next feed hydrological simulations, along with climate scenarios (obtained from climate ensembles in CMIP6, 2021) that condition water availability. If hydrologic simulation outputs show an impact on physical constraints of relevance for economic agents (such as a new binding water availability constraint), the process continues with a new iteration to assess further adaptation responses in the human system. This iterative process can be repeated until convergence is reached (Essenfelder et al., 2018).

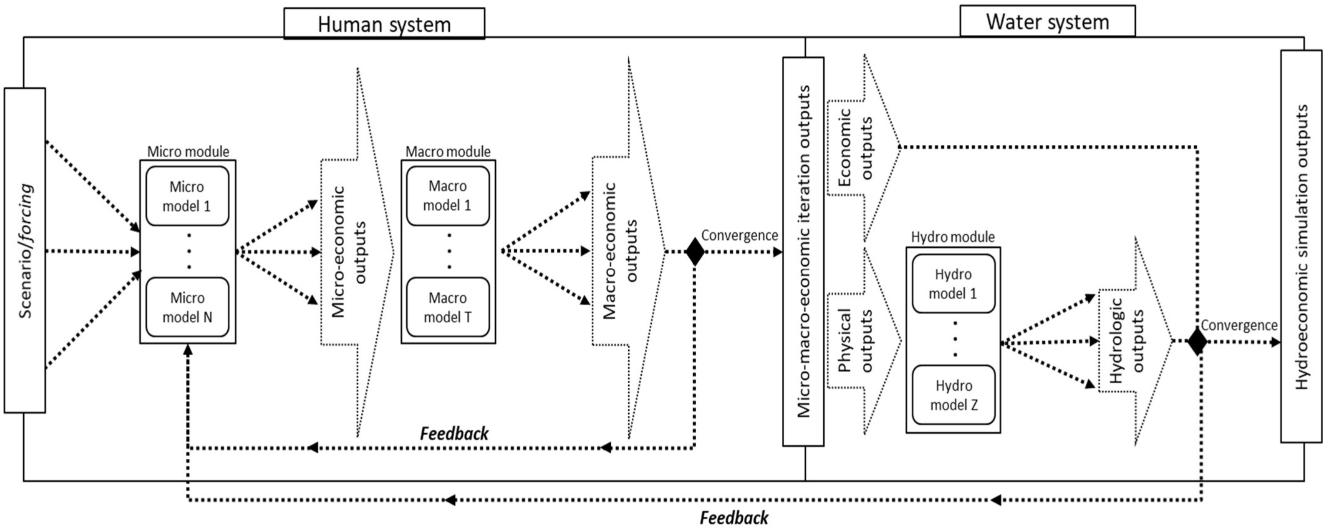

Figure 4 The Cega Water Lab multi-system modular hierarchy

This is one possible setting of the flexible and replicable hierarchy framework targeting the assessment of pressures introduced in human-water systems by a water conservation policy in the context of the Cega Water Lab. The hierarchy will be populated with several models per system, to carry out ensemble experiments that assess the implications of alternative initial states and forcings based on *a priori* knowledge. Other modules and protocols will be developed and used, notably by including a time-variant/dynamic setting—i.e., instead of looking for convergence, information is carried forward in time. Note that as we include additional modules and protocols, models and scenarios, uncertainties compound. Far from being negative, this outcome is desirable: navigating deep uncertainty type 1 necessitates a thorough sampling of possible futures that goes beyond consolidative modeling and point predictions, so to identify *robust* policies that perform reasonably well in most conceivable situations (Groves et al., 2015; Haasnoot et al., 2013).

The data inputs needed to run this modeling hierarchy are described in the metadata file.

b. Metadata

The Metadata file is viewable here : [TALANOA_Sourcebook_Metadata - Google Sheets]

c. Perspectives in terms of data collection, validation, and data gaps

The Cega Water Lab has already collected all the hard data necessary to run the modeling hierarchy presented above; as well as all the necessary remote sensing data to build the water accounting sheets of the Cega Basin, which have been already submitted to the Accounting Data coordinator (Hadi Jaafar, AUB). A preliminary version of the water consumption and biomass production simulations obtained processing the remote sensing data for the Cega Water Lab has been produced by AUB.

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9. Tunisia : Jeffara plain

a. Presentation of the modeling ambition in the lab

The pilot area considered by the Tunisian Water Lab is the Jeffara plain. A Ahydrogeological modelling using MODFLOW (groundwater flow model) and WEAP (water planning model), coupling water resources (surface and groundwater) with different uses (Haddad et al. 2013) as well as through the hydraulic infrastructure and including the socio-economic aspects.

The Tunisian water lab will need more details data and information on how hydrological, social, and economic aspects will impact agriculture production and citizens welfare in water scarcity context accentuated by water quality (salinity) increasing problems (Ben Hammouda et al., 2021; Nefzaoui et al., 2021). This water salinity problem constraigning currently agriculture production will be a focus of the Water Lab of Jeffara to bring scientif and practical solutions helping farmers improving their economic profitability and the sustainability of their lands. To this end, we plan to extend the modelling effort to water salinity dynamics et its possible future trend over the existing aquifers in the studied plain.

For this reason, we propose to use the social, economic, and hydrological data to develop tailored thematic models and to couple them using a computing platform (WEAP for example) in a harmonized way. The ambition is to make available for the water lab a simulation platform that supports stakeholders dialogue by providing answers to any question: what if? The following diagram explainsexplain the modeling ambition:

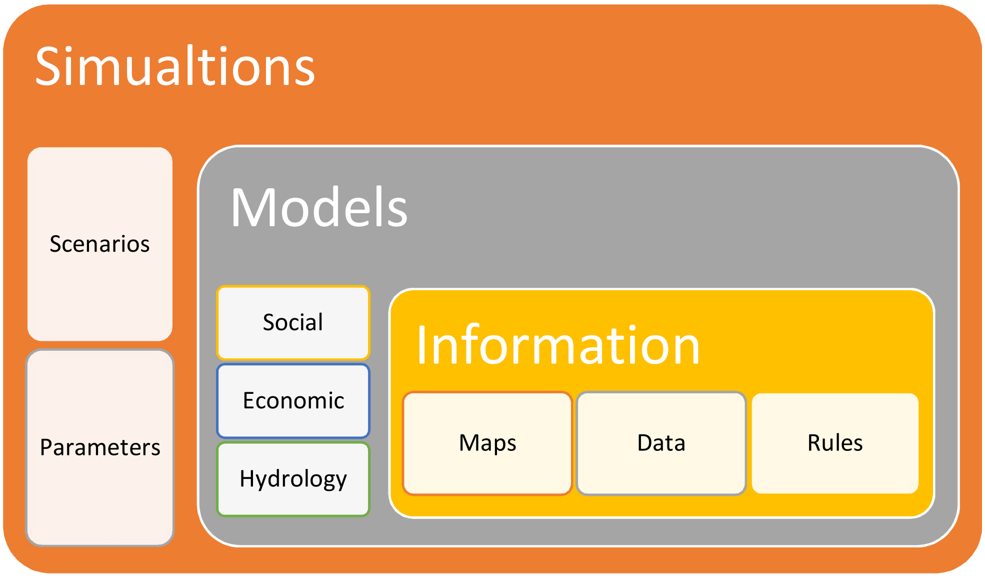

Figure 5. Ambition of the socio-hydrology modelling for the Tunisian Water Lab

b. Metadata

Table 1. HEAC metadatabase for the Tunisia Lab

Data Inputs

id.	cat.	type	name	variables	owner	time Start	time End	time step	location	resolution	method	use	open	restrictions	collected	uploaded	link
1	HYDRO	MODFLOW files	MF_files_MED		CRDA Medenine/INAT/CRNSTN	1982	2015	Month	Jeffara plain	250x250 m	Maps digitalization (GIS), Time series processing	MODFLOW	0	1	1	0	
2	HYDRO	Geologic map	GEO_MED		CRDA Medenine/INAT/Other universities				Jeffara plain			MODFLOW	0	1	1	0	
3	HYDRO	Groundwater levels in monitoring wells	PIEZO_MED	Level (m)	CRDA Medenine	1982	2020	6 Monthly	Jeffara plain		Ground sampling/piezometers/Datalogger	MODFLOW	0	1	1	0	
4	HYDRO	Locations of monitoring wells	PIEZO_MAP_MED		CRDA Medenine	1982	2020		Jeffara plain		GPS	MODFLOW	0	1	1	0	
5	HYDRO	Pumped volume - public wells	PUMPING_PUB_MED	Flow (CMS)	CRDA Medenine/SONEDE	1982	2020	Monthly	Jeffara plain		Flow meter	MODFLOW	0	1	1	0	
6	HYDRO	Pumped volume - private wells	PUMPING_PRIV_MED	Flow (CMS)													
7	HYDRO	Pumped volume - illegal wells	PUMPING_ILLIG_MED	Flow (CMS)													
8	HYDRO	Stream flows	STREAM_MED	Flow (CMS)	CRDA Medenine												
9	HYDRO	Inter-basin transfers	TRANSFER_MED	Flow (CMS)	CRDA Medenine/INAT	1982	2020		Jeffara plain		Flow meter	WEAP	0	1	0	0	
10	CLIMATE	Precipitation	PLUIE_MED	Rain (mm)	CRDA Medenine/Web sites/INM	1982	2020	Monthly	Jeffara plain		Rain gauge/open source data	WEAP/SWAT	0	1	1	0	
11	CLIMATE	Temperature - Daily max	TRE_MED	Temperature (°C)	CRDA Medenine/Web sites/INM	1982	2020	Monthly	Jeffara plain		Meterological station	WEAP/SWAT	0	1	1	0	
12	CLIMATE	Temperature - Daily min	TRE_MED	Temperature (°C)	CRDA Medenine/Web sites/INM	1982	2020	Monthly	Jeffara plain		Meterological station	WEAP/SWAT	0	1	1	0	
13	CLIMATE	Evaporation	EVAP_MED	Evaporation (mm)													
14	CLIMATE	Relative humidity	RH_MED	Humidity (%)	Web sites/INM	1982	2020	Monthly	Jeffara plain		Meterological station	WEAP/SWAT	0	1	0	0	
15	CLIMATE	Wind speed	WS_MED	Wind speed (Km/h)	Web sites/INM	1982	2020	Monthly	Jeffara plain		Meterological station	WEAP/SWAT	0	1	0	0	
16	CLIMATE	Solar radiation	SR_MED	Radiation	Web sites/INM	1982	2020	Monthly	Jeffara plain		Meterological station	WEAP/SWAT	0	1	0	0	
17	CLIMATE	Sunshine hours	SUN_MED	Sun shine (Hours)	Web sites/INM	1982	2020	Monthly	Jeffara plain		Meterological station	WEAP/SWAT	0	1	0	0	
18	GIS	Crop-type map	OCCUPATION_SOL_MED		CRDA Medenine/URAP												
19	GIS	Soil map	SOIL_MED		CRDA Medenine/FAO/Thesis/Master												
20	GIS	DEM	DEM_MED		Web site/INAT												
21	GIS	Land use class map	CARTE_AGRICOLE_MED		CRDA Medenine/URA			yearly	Jeffara plain			SWAT	0	1	0	0	
22	LAND USE	Land use classes table	BD_AGRI_MED		CRDA Medenine/URAP/satellite images			yearly	Jeffara plain			SWAT	0	1	0	0	
23	HYDRO	Wastewater plant discharge	EUT_MED	Flow (CMS)	ONAS			Monthly	Medenine city		Flow meter	WEAP/SWAT	0	1	0	0	
24	HYDRO	Water quality parameters	WQ_MED		ONAS/sampling/Other projects/Thesis/Master			Monthly	Medenine city		Flow meter	WEAP/SWAT	0	1	0	0	
25	ECONOMIC	Mean crop yield statistics	CROP_MED	Yield (Kg/ha)	CRDA Medenine/INAT/IRA Medenine				Jeffara plain		Survey	WEAP	1	0	0	0	
26	ECONOMIC	Average market prices	PRICES_MED	Unit proice (USD/kg	CRDA Medenine/INAT/IRA Medenine				Jeffara plain		Survey	WEAP	1	0	0	0	
27	ECONOMIC	Average cost of agriculture inputs	PRICES_MED	Unit cost (USD/kg)	CRDA Medenine/INAT/IRA Medenine				Jeffara plain		Survey	WEAP	1	0	0	0	
28	ECONOMIC	Labour costs	PRICES_MED	Salary (USD/month	CRDA Medenine/INAT/IRA Medenine				Jeffara plain		Survey	WEAP	1	0	0	0	
29	ECONOMIC	Investment unit costs	PRICES_MED	Unit Investment cos	CRDA Medenine/INAT/IRA Medenine				Jeffara plain		Survey	WEAP	1	0	0	0	
30	ECONOMIC	Production costs	COSTS_MED	Unit Production cos	CRDA Medenine/INAT/IRA Medenine				Jeffara plain		Survey	WEAP	1	0	0	0	
31	ECONOMIC	Management costs	COSTS_MED	Unit management c	CRDA Medenine/INAT/IRA Medenine				Jeffara plain		Survey	WEAP	1	0	0	0	

see [TALANOA_Sourcebook_Metadata - Google Sheets]

c. Perspectives in terms of data collection, validation, and data gaps

Since the beginning of the TALANOA project, about 30% of the data needed was collected from official departments. Mainly, we collected most of the climatic data as well as hydrological, geological, and social ones. Economic data requires ground surveys as well as face-to-face contacts with local and regional administration and organizations, whichwhat requires trips to the study area and the availability of the budget (made available only on November 2021). To fill this gap, we plan to ensure a campaign of data collection in the Jeffara plain in the first trimester of 2022. The mission will target previous national and international projects dedicated to water management, transfer of technologies, and agriculture production in southern Tunisia.

d. References

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10. Conclusion & perspective

The metadata and databases must be seen as evolutionary throughout the project as both the science and the participation of TALANOA Water labs will be developed during the project and might identify the need for - or produce - new datasets. These will be updated in the metadata base and database with respect to guidelines and principles of the data management plan (D.5.2). A new version of the metadata will be made available and harmonized for about month 16.

11. General references

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