NEXUS-NESS

NEXUS NATURE ECOSYSTEM SOCIETY SOLUTION

Fair and sustainable resource allocation demonstrator of the multiple WEFE Nexus economic, social and environmental benefits for Mediterranean regions

GRANT AGREEMENT NUMBER 2042

Deliverable D3.3
WEFE NEXUS indicators and related dataset
V1.1 30 October 2022

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WP3 Leader SSSA, Rudy Rossetto. Task 3.3 Leader UNIFI, Enrica Caporali

NEXUS-NESS - NEXUS NATURE ECOSYSTEM SOCIETY SOLUTION: FAIR AND SUSTAINABLE RESOURCE ALLOCATION DEMONSTRATOR OF THE MULTIPLE WEFE NEXUS ECONOMIC, SOCIAL AND ENVIRONMENTAL BENEFITS FOR MEDITERRANEAN REGIONS

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WP- Main Beneficiary	SSSA		
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Abstract	This report defines the use of indicators to monitor the evolution of the different WEFE Nexus dimensions (i.e. Water, Energy, Food and Ecosystems) in the Nexus Ecosystem Labs (NELs)		
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Executive summary

This deliverable D3.3 aims at defining the use of indicators to monitor the evolution of the different WEFE Nexus dimensions (i.e. Water, Energy, Food and Ecosystems) in the Nexus Ecosystem Labs (NELs). The use of indicators is crucial to produce information that efficiently communicates the characteristics and trends of Nexus in the NELs, making it possible for project partners and stakeholders to understand the conditions, trends and rate of change determined by different intervention scenarios included in the Nexus management plans.

The present deliverable is strongly connected to the deliverable 5.1 that sets the framework for the development of indicators to support the assessment of the socio-economic and environmental impacts of a WEFE Nexus-based transition strategy. The indicators described in the deliverable 5.1 are here filtered and selected with a two-tiers evaluation methodology according to the specific context of the NELs and their specific grand challenges. Firstly, a set of base indicators are defined to evaluate the “as it is" and “as it should be” scenarios in all the NELs. Afterwards, a detailed analysis of each NEL grand challenge is carried out describing the subset of indicators suggested to be used.

1. Introduction

The use of indicators within the Nexus Ness project is a pivotal element to funnel the work done in the different WPs towards the identification of the most appropriate WEFE Nexus based management strategies and the definition of the WEFE Nexus Management plans. Indeed, summarising the different dimensions of the WEFE Nexus and their interrelationships into indicators can support a better understanding of Nexus itself by both expert and non-expert audience thus enabling the transition towards a WEFE Nexus approach in managing socio-ecological systems.

This deliverable aims at defining how to use indicators to evaluate the different WEFE Nexus dimensions (i.e. Water, Energy, Food and Ecosystems), setting a baseline for analysing the potential transition paths in the NELs. Therefore, the use of indicators emerges as fundamental to summarise the analysis carried out within the WP4 (in particular with the WatNeeds and Freewat models outputs) and to make them exploitable within the Multi Stakeholder and User Platform (MSUP). The indicators will also support the socio-environmental-economic integrated assessment developed in WP5 (e.g. cost benefit analysis). Given the strong participatory nature of the Nexus Ness project, the use of indicators becomes crucial to achieve a higher level of participation in the NELs (WP3), allowing the translation of the complexity of the Nexus into information which is understandable by a wider public.

The deliverable 3.3 in this first release sets the basis for the use of the indicators described in the deliverable 5.1 to assess the WEFE Nexus in the NELs. The two-tiers evaluation methodology introduced in the second chapter defines the suggested analysis procedure starting from the definition of a WEFE Nexus Index. This index is a combination of indicators that can be used to measure the WEFE Nexus in present and future scenarios in each NEL. Parallel to the definition of the WEFE Nexus Index, a subset of indicators is selected to analyse the grand challenges identified in the NELs.

In chapter 3, a detailed analysis of each NEL is carried out, describing the WEFE Index composition in each NEL and then clarifying the connections among the grand challenges and the indicators to be used in order to assess the performance of the solutions proposed.

2. The methodological approach

This section describes the methodology that is used to assess the WEFE Nexus within each NEL through the indicators already proposed in the Deliverable 5.1. Therefore, each indicator is named with the code introduced in the Deliverable 5.1, where the whole first tentative catalogue of indicators is presented. The proposed methodology is useful to describe the WEFE NEXUS development in a given NEL, assessing each sector as well as their interdependencies within the NEL, and it can be also used to shape the best management plan to address each NEL Grand Challenges (described in Deliverable 3.1). When some important parameter useful to describe a sector or a grand challenge is not present in the Deliverable 5.1, a new indicator is proposed following the same approach - in the rationale that the first catalogue of indicators provided in Deliverable 5.1 issued in September 2022 is to be developed via the appropriation and testing by other tasks and by NEL's stakeholders; and improved in the next version of Deliverable 5.1.

The WEFE Nexus can be measured and monitored with indicators at different spatial and temporal scales/levels of organisation. Indeed, as already clarified in Deliverable 5.1, the spatial scales/levels that can be involved are for instance the Farm scale, the NEL scale or the Society scale, while the temporal scales are the short-term/daily (operational), the weekly/seasonal (tactical) decisions/actions or the long-term (strategic) orientations.

The methodology is divided into two parts and each part has its own spatial and temporal scale:

- Definition of a WEFE Nexus Index (common for all the NELs) that will be used to give a concise representation of the Nexus in the NELs in the present situation and future scenarios.
- Definition of sets of indicators tailored to NEL needs, based on a common list/catalogue. The indicators will be used to assess the benefits and trade-offs that the proposed solutions introduce in the NEL (intervention scale) and to support the cost-benefit analysis.

In the first part, four indicators will be combined into a single metric, the WEFE Nexus Index (WNI) that will describe the development of the Nexus in each NEL (left part of Figure 1). The WNI will give a measure at the NEL scale of the WEFE Nexus in the present scenario, "as it is", and will be used to monitor the improvements in the future scenario, "as it should be". The four indicators included in the WNI will describe each dimension of the NEXUS: the water dimension will be measured in terms of water availability in the NEL and will be described with the indicator WA1, i.e. the sum of the total renewable water resources per capita (m3/person); the energy dimension will be described by the indicator ENC1 that is the total energy consumption per capita (kwh/person); the food dimension will be assessed with the indicator FP1, the crop productivity of all the farms in the NEL (ton/ha); the ecosystem dimension will be based on a subset of three indicators to take into account the interrelationships between the ecological component and the other three dimension of the nexus. In particular, the ecosystem dimension will be evaluated using dedicated indicators to quantify the impacts on the ecological health of the system determined by:

- Agriculture sector with the indicator EC7 (kg/ha), a new indicator which represents the amount of fertilisers used in agriculture and spread in the NEL ecosystem;
- Energy sector with the indicator ENC4 (%), i.e the Renewable energy share in total final energy consumption;
- Water sector with the indicator EC4 (qualitative classes), which represents the water quality of the main reach of the NEL.

In the Deliverable 5.1, there is not a specific indicator that can assess the impact of the Food sector on the Ecosystem. For this reason, EC7 has been introduced in this deliverable. EC7 can be evaluated with local surveys in the NEL farms or with remote sensing data, as concentration of some nutrients in the soil (phosphorus or potassium) can be retrieved with satellite imagery. In the Deliverable 5.1, EC4 had a different meaning, as it was expressed as the "Proportion of water bodies with Good Ambient Water Quality" and it was meant to be applied especially at higher spatial scales. Nevertheless, since the spatial scale decided to evaluate WNI is only the NEL scale, the EC4 is better described with the quality of the main reach, rather than a percentage of water bodies in the NEL.

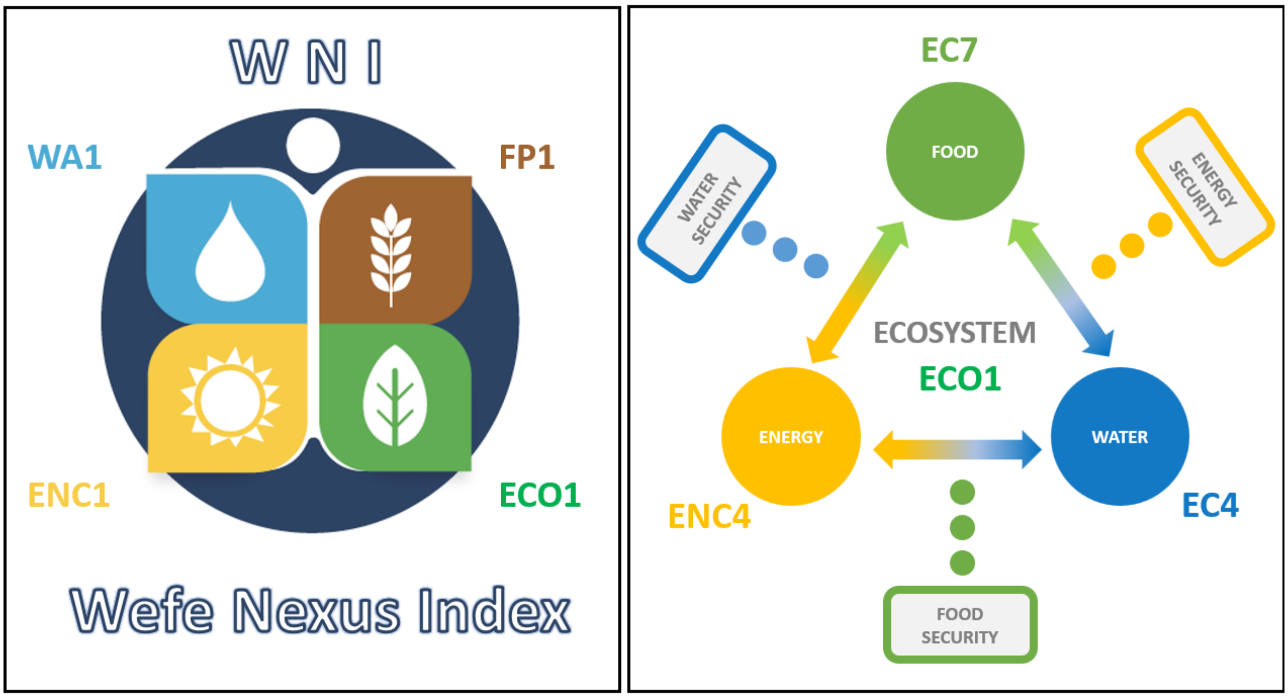


Figure 1. WEFE NExus Index based on the six indicators: WA1, ENC1, FP1 and ECO1, which is evaluated with EC4, ENC4 and EC7.

The six indicators that are needed to evaluate the WEFE Nexus Index (WA1, ENC1, FP1 and ECO1) are the same in each NEL and will be better described in the following sections, where also all the sources of data for their calculation are provided, while the general methodology for the evaluation of WNI is presented below. Since all the indicators have different metrics, there is a need for an homogenisation to aggregate them into a single index.

A first homogenization is done with the three indicators used to evaluate ECO1. Particularly, EC4 (the water quality of the main reach of the NEL) can follow the classification that is already available in Europe thanks to the Water Framework Directive (2000/60/EC), which assigns a qualitative assessment (bad, poor, moderate, good and high quality), based on water quality monitoring. The African NELs can assess the quality of the main river following the same classification, applying an expert-based evaluation. Then, the qualitative assessment for the water quality can be converted in numbers with a score from 1, bad, to 5, high.

The ENC4 (renewable energy share in total final energy consumption) is already expressed as a percentage and it can vary from 0 to 100. Also in this case, ENC4 can be expressed with a score from 1 to 5 depending on its value (1 if $0 \le ENC4 \le 20\%$, 2 with $20 < ENC4 \le 40$, 3 with $40 < ENC4 \le 60$, 4 with $60 < ENC4 \le 80$ and 5 with $80 < ENC4 \le 100$).

The amount of fertilisers spread in the environment can be classified according to the quality standards set by national regulations which give the maximum threshold for each substance in the environment. Therefore, the score of EC7 (amount of fertilisers used in agriculture) can vary from 1, if the amount of fertilisers is over the maximum quantity set from the quality standard, to 5 if the concentration in the environment is close to 0. All the other values can be assigned dividing the range into 5 parts. After evaluating EC4, ENC4 and EC7, ECO1 is calculated as the mean of the three scores that will also vary between 1 and 5.

The assessment of the other indicators (WA1, ENC1, FP1) is described in the following section for each NEL. Nevertheless, also in this case there is a need for a homogenization, to aggregate them with ECO1. The approach that is followed for this second homogenization is the same already described for ECO1 and all the indicators will be converted into a 1 to 5 score, dividing the range of each indicator into 5 groups. Therefore, there is a need to determine the range in which the indicators can vary within each NEL.

WA1 (total renewable water resources per capita) is transformed into a score based on the concept of water scarcity. Indeed, the regions with “absolute water scarcity” are defined as those with less than 500 m3 per year per capita, while the regions with “water stress conditions” are those with an amount of freshwater between 500 and 1000 m3 per year per capita. For this reason, WA1 will be 5 if the water used per capita is over 1000 m3, 3 if it is between 750 and 1000 m3, 2 if it is between 500 and 750 and 1 if the NEL face the absolute water scarcity, i.e. the water used per capita per year is under 500 m3.

The crop productivity depends on each NEL on the area that is used for agriculture. Therefore, FP1 (crop productivity of all the farms in the NEL) is zero if there are no agricultural areas, while its maximum value can be calculated assuming that all the available areas in the NEL are used for agriculture. Therefore, the maximum value of FP1 can be evaluated by analysing the land use and assuming that there are no water availability constraints to produce crops. Then, the range will be again divided into classes and the actual Food Production FP1 will be replaced with a score from 1 to 5.

As for the water and food sector, also for the energy sub-nexus level, the more energy is produced in the NEL, the higher is the score that is associated with the indicator. Nevertheless, energy production is really difficult to evaluate at the NEL scale, while energy consumption is easier to assess. For this reason energy consumption is adopted as an indicator for the energy dimension, also considering its high correlation with energy production. The homogenization of ENC1 (total energy consumption per capita) is done considering the average energy consumption in the Mediterranean basin (referring to the list of countries included within the Mediterranean Action Plan of the Barcelona Convention). The normalisation is made with the percentiles obtained with the average energy consumption values (per capita) of the twenty considered countries, available in the open dataset of EIA (U.S. Energy Information Administration 2018, 2019). For this reason, ENC1 will be 1 if the the yearly energy consumption per capita is less than 1471, 2 if it is between 1472 and 3362, 3 if it is between 3363 and 4457, 4 if it is between 4458 and 5068 and 5 if the NEL has an average energy consumption per capita over 5069 m3.

In the second part of the methodology, the indicators are Grand Challenge specific and they can differ among each NEL. Indeed, in this case, the indicators are needed to assess if some proposed solutions to progress on a given Grand Challenge can be effective. Since each NEL faces different problems, a specific set of indicators is chosen from the Deliverable 5.1 for each Grand Challenge. Nevertheless, the indicators in this second phase are not meant to evaluate all the metrics regarding Water - Energy - Food - Ecosystem at the NEL scale, but are thought for assessing just the changes that the proposed solution entails in the case study. Therefore, for instance, if a given solution is applied to increase the water availability with unconventional sources (WA2 in Deliverable 5.1), WA2 will not refer to all the unconventional water sources in the NEL, including those already present before the intervention (“as it is scenario”), but just on the amount of water that the proposed solution will introduce in the NEL (“as it should be scenario”). In this way, the indicators can also be useful to serve a Cost Benefit Analysis (CBA) assessment to decide among different solutions for the same Grand Challenge.

In the following section of this Deliverable, the indicators are shown in matrices, and each cell represents a sub-nexus level. The matrix must be read from the left: Figure 2a shows the water to produce energy (evaluated with the indicator WU7), while Figure 2b shows the energy to produce water (evaluated with the indicator ENC2). Therefore, for instance, a solution that increases the energy with hydropower is placed on the first row and second column (WU7), while a plan to increase the water availability through the pumping from groundwater or a water treatment plant will be on the second row and first column (ENC2).

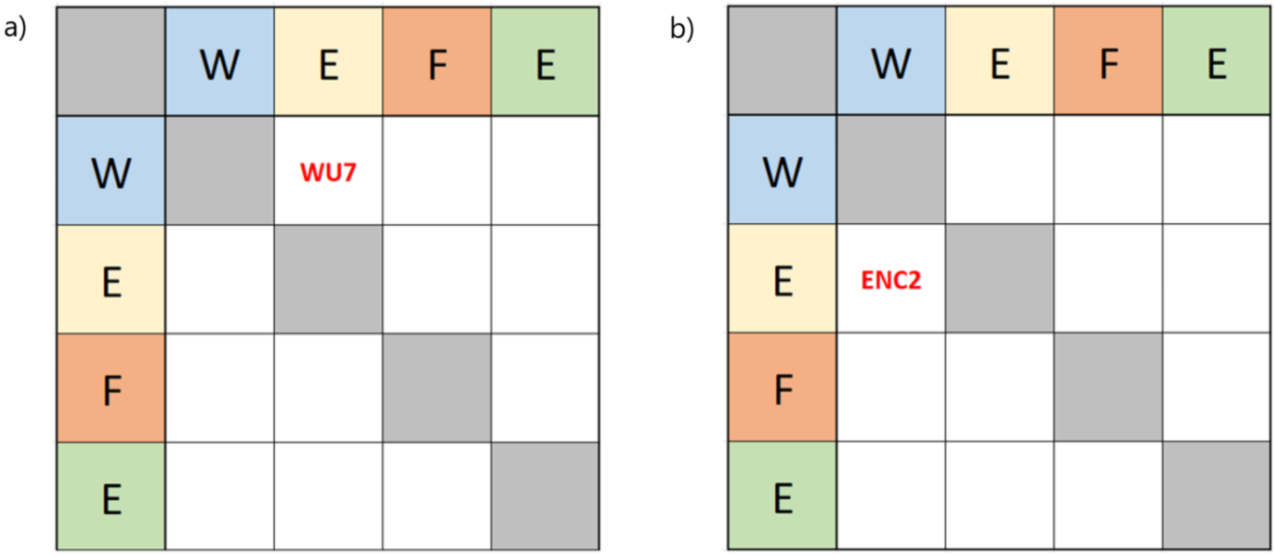


Figure 2. a) Water to produce energy (WU7); b) energy used to increase water availability (ENC2).

Furthermore, the indicators are linked across the cells with arrows to show the interdependencies and trade-offs between each resource and sector.

3. Measuring the Nexus in the NELs

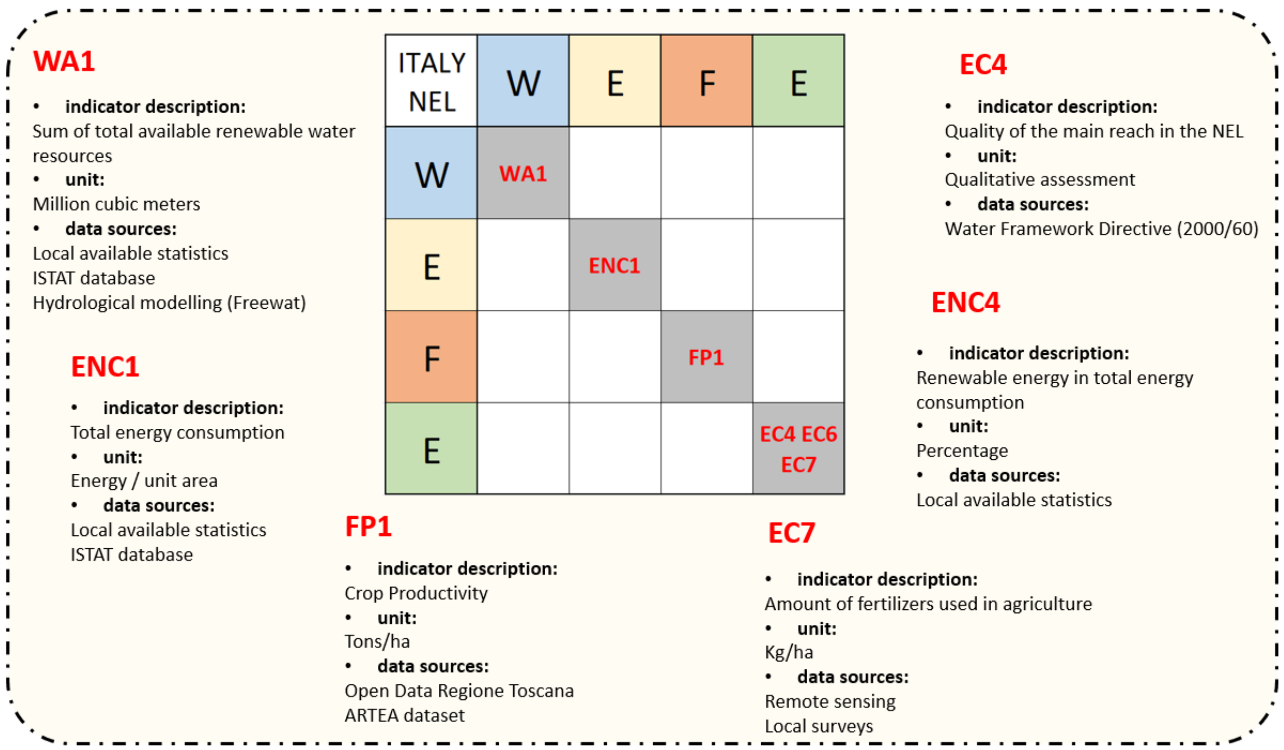
This section describes how to evaluate the indicators used to assess the WEFE Nexus Index in each NEL and how to measure the benefits and trade-offs of the solution proposed to face the grand challenges in each NEL. This section aims at producing practical guides that can be followed for the calculation of indicators in each NEL. Therefore, the section is divided into four paragraphs, one for each NEL: Italy (3.1), Spain (3.2), Egypt (3.3) and Tunisia (3.4). Each paragraph is meant to be independent from the others. In this way, the readers can easily understand how to evaluate the selected indicator (and the possible data sources) in a given NEL without reading the entire deliverable. For this reason, some information is repeated in several parts of the section.

Each paragraph is then divided, as the methodology, into two parts. First, the four indicators used to assess the WEFE Nexus at the NEL scale (WNI) are described. Particularly, the source of data for each NEL is presented. Second, all the indicators to evaluate the potential benefits and trade-offs of the proposed solution for each Grand Challenge are described.

3.1 ITALY

3.1.1 <u>WEFE Nexus Indicators at the NEL scale</u>

This first part of this section presents the indicators and the source of data useful to measure and assess the WEFE Nexus Index at the NEL scale in Italy. The information is contained in the following figure.



Regarding the water availability in the Italian NEL, the indicator WA1 describes the sum of the total available renewable water resources. This information can be derived from the national institute of statistics ISTAT or from the Freewat model, which must be implemented in each NEL to assess the surface and groundwater availability at the watershed scale. The ISTAT database can be also useful to obtain information about the total energy consumption (ENC1), which is given for regions and provinces at the yearly scale. Therefore, if finer spatial and temporal data are not available, there will be the need to downscale the information from the province to the NEL scale. At the same time, the information should also be temporally disaggregated, as the indicators should be evaluated in each season. The food production will be assessed with the Crop Productivity (FP1), and this information is available in the open data of the Tuscany Region. Particularly, the information is provided by Tuscan Regional Company For Agricultural Supplies, ARTEA ("Azienda Regionale Toscana Per Le Erogazioni In Agricoltura" in Italian). The quality of the main reach of the NEL (EC4) can be obtained from the work done by the Northern Apennine District ("Autorità dell'Appennino Settentrionale" in Italian) which classified the river bodies in the area applying the regulation of the european Water Directive (2000/60/CE). The quality of the water bodies has been done for the second time recently with the last classification in 2021. The carbon footprint at the NEL scale (EC6) will be evaluated with local statistics or will be assessed with GIS information. The amount of fertilisers used in agriculture (EC7), as already mentioned in the previous section, can be evaluated with local surveys in the farms or with remote sensing data

3.1.2 Grand Challenge in the Italian NEL

The grand challenges in the Italian NEL consist of allocating new available non-conventional water resources in the agricultural sector to boost food production and avoid the over-exploitation of groundwater availability.

Grand Challenge 1

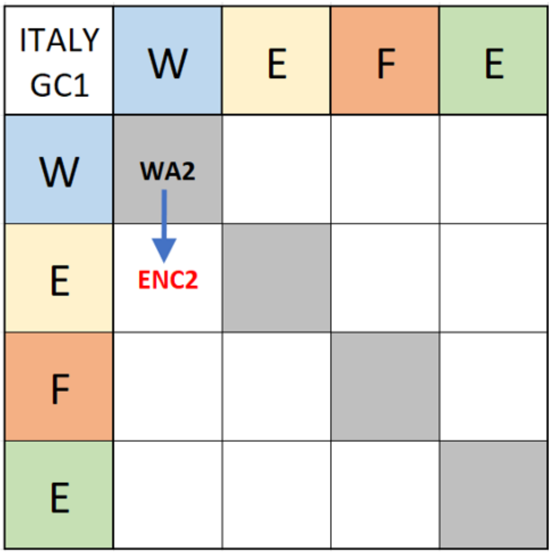
The GC1 proposes to irrigate with treated wastewater reuse, which represents a new source of unconventional water use (WA2). As already mentioned, the WA2 represents just the amount of water that the intervention will introduce in the NEL in a given season. Therefore to quantify the amount of water that can be treated in a given season and estimate the indicator, only the capacity inlet flow rate of the treatment plant is necessary.

ITALY GC1	W	E	F	E
W	WA2			
E				
F				
E				

WA2

- **indicator description:**
New non-conventional water resources
- **unit:**
Million cubic meters
- **data sources:**
Capacity Inlet Flow Rate of the treatment plant (cubic meter/hour)

The production of unconventional water resources implies a trade-off in energy consumption. Nevertheless, the total energy consumption (ENC1) could also decrease in the future, even with an increase of the water availability. Indeed, the energy for wastewater treatment (ENC2) balances the avoided electricity that would have been used to pump the same amount of water from the ground. Therefore, the current scenario would be compared with the intervention scenario to evaluate if there is a saving or an increase in electricity consumption (ENC1).



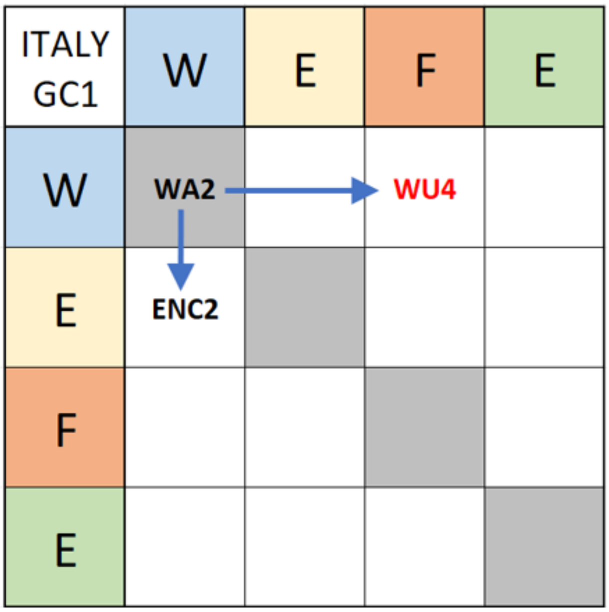
ENC2

- **indicator description:**
ENC2: Energy consumption declined by sectors (energy for water)

- **unit:**
Energy / sector

- **data sources:**
Energy required to treat water and energy saved for avoided water pumping from groundwater

The production of unconventional water resources will increase the blue water that is given in agriculture (WU4) and maybe also enhance the crop water productivity (FP2), i.e. the amount of harvested product per unit of irrigated water.



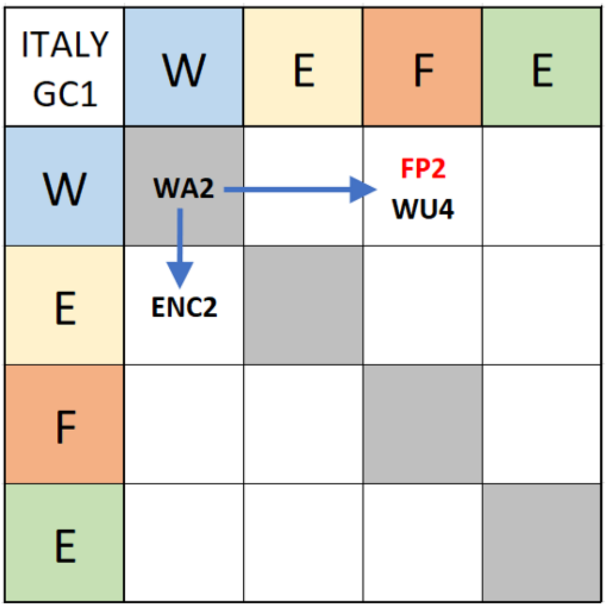
WU4

- **indicator description:**
Blue Water footprint

- **unit:**
Volume/unit area

- **data sources:**
Percentage of the treated water used for irrigation from local statistic

The crop water productivity can be evaluated by comparing the results of the Waterneeds model with the ARTEA open dataset of the Tuscany region.



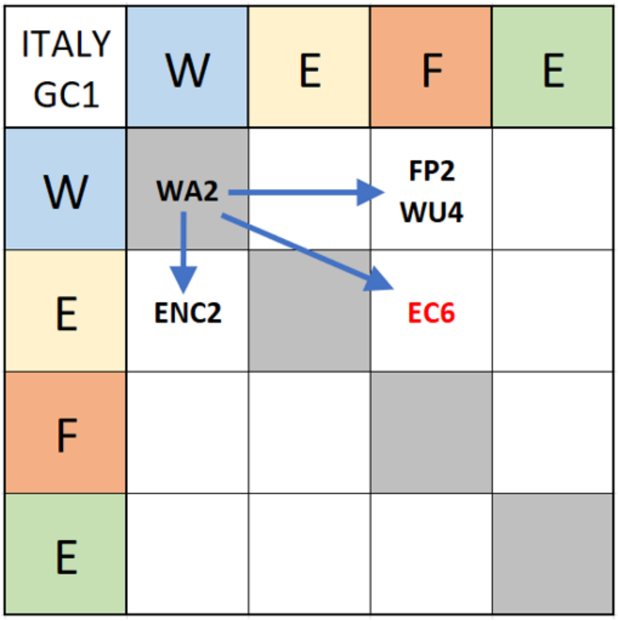
FP2

- **indicator description:**
Tons of harvest production per unit of irrigated water

- **unit:**
Tons/unit volume of water

- **data sources:**
Regional statistic (ARTEA dataset)
Watneeds output

The increase of the crop water productivity could be due to the presence of nutrients in the treated wastewater. This aspect could not only have a positive benefit with the crop water productivity, but also on the Energy for Food sub-nexus level. Indeed, the treated water can reduce the amount of fertilisers that are needed in agriculture. This aspect can be monitored with EC6, the changes of Carbon Footprint that the proposed solution introduced in the NEL.



EC6

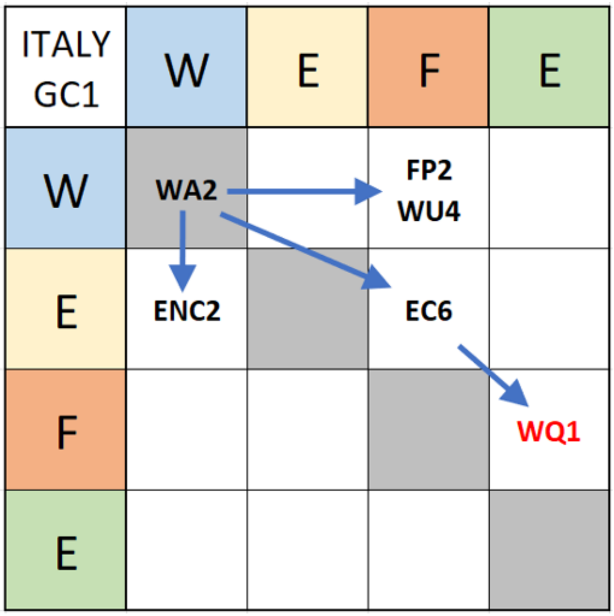
- **indicator description:**
Carbon footprint

- **unit:**
Equivalent CO_2/ unit area

- **data sources:**
CO_2 in fertilizers production by literature

EC6 in this case measures the net carbon footprint at the NEL scale [ton/m^2], i.e. it does not account for all the different sources of carbon dioxide within the NEL, while it considers only the changes in the CO_2 production in the NEL following the WEFE plan introduced to face the grand challenge. The direction (positive or negative) of the net CO_2 production for the new source of water cannot be easily understood in advance, as there is a need to know if the avoided energy for groundwater pumping is more or less with respect to the energy used to treat water. Nevertheless, it is clear that irrigating with treated wastewater will decrease the energy for fertiliser production (energy for food), as less fertiliser will be needed in the soil (EC7).

At the same time, less fertiliser in the soil will also positively affect the ecosystem, as a lower amount of pollutants is released into the environment. Therefore, this aspect will be monitored with the WQ1 indicator, which represents the grey water, i.e. the amount of freshwater required to assimilate pollutants in the production process to meet water quality standards.



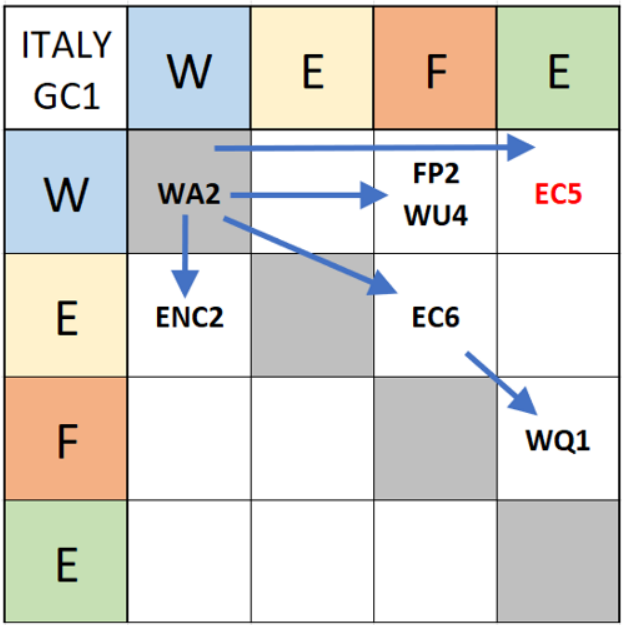
WQ1

- **indicator description:**
Grey water footprint
- **unit:**
Volume/unit area
- **data sources:**
National and regional regulations on water quality

The reduction of the Grey Water can be easily retrieved knowing the amount of fertilisers that is saved thanks to the irrigation with treated wastewater. Indeed, assuming a given composition of the fertilisers, the water needed to respect the maximum concentration that can be spreaded in the environment for each component represents the Gray Water. The water quality standards are defined in national and regional regulations.

The new allocation of treated wastewater (WA2) also synergises with the Water for the Ecosystem sub-nexus level. Indeed, there are two positive benefits for the ecosystem of the italian NEL: first it will improve the effluent quality (EC5); second, it will avoid groundwater over-exploitation (WU5).

EC5 is defined in the Deliverable 5.1 as a score that is attributed based on "how the farmer deals with the effluent". Therefore, a better effluent treatment is correlated with higher scores. The quality of the effluent does not depend on how the farmers deal with the water quality in the Italian grand challenge. Indeed, the water quality will be improved thanks to the wastewater treatment plant. Nevertheless, the parameter can be used with the same purpose to monitor the improved quality of the effluent.



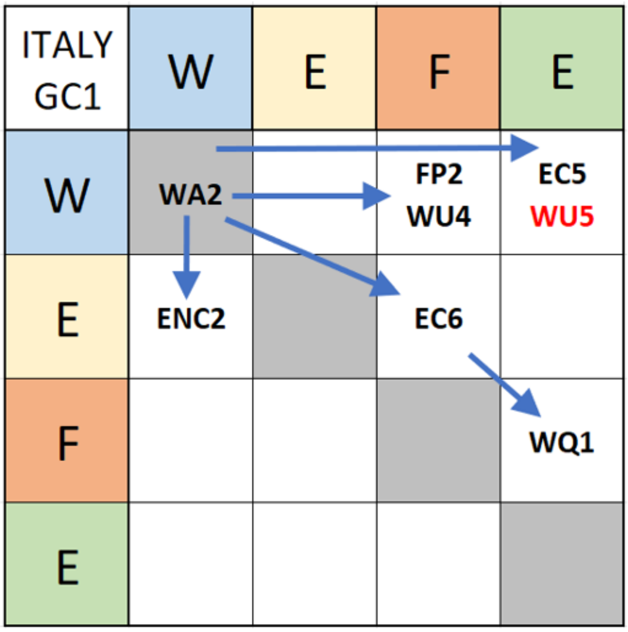
EC5

- **indicator description:**
Effluent processing

- **unit:**
Score

- **data sources:**
Local statistics

In the Deliverable 5.1, WU5 represents the drop in groundwater level, i.e. the distance of the water table from the ground. In this case, the data source for the evaluation of the indicator will be the Freewat model, which can give this kind of information as it is suitable for hydrological balance of surface and groundwater. Nonetheless, in this case the indicator will not evaluate drop in groundwater level, while it will assess the positive effect that the proposed solution will introduce as avoided over-exploitation. Therefore, the indicator in the current scenario (as it is) should be higher than in the intervention scenario (as it should be).



WU5

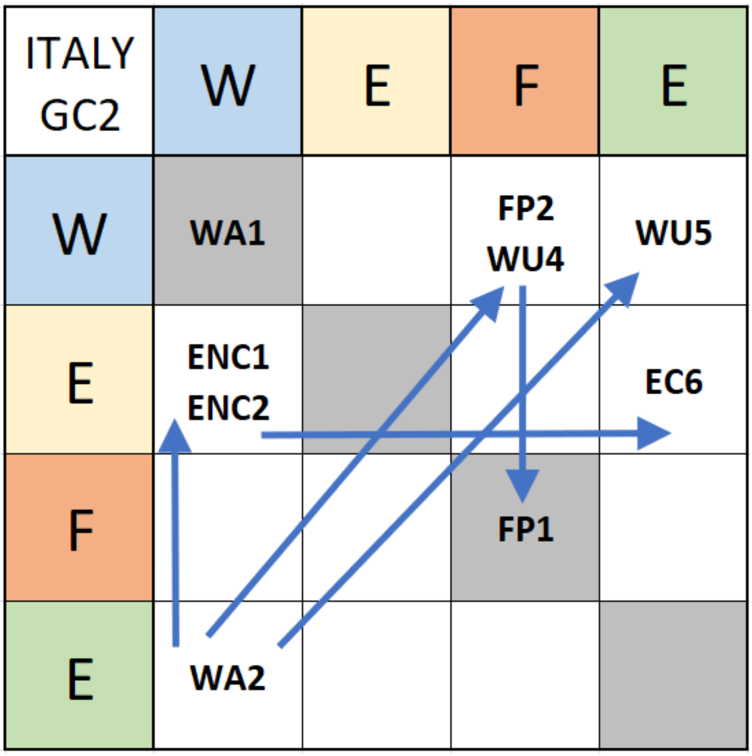
- **indicator description:**
Over-exploitation

- **unit:**
Meter

- **data sources:**
Freewat model output

Grand Challenge 2

For the second grand challenge all the indicators are directly shown together into a single matrix, as they are the same already described for the first grand challenge. The description of the trade-off and synergies is described with the arrows and explained below the figure.

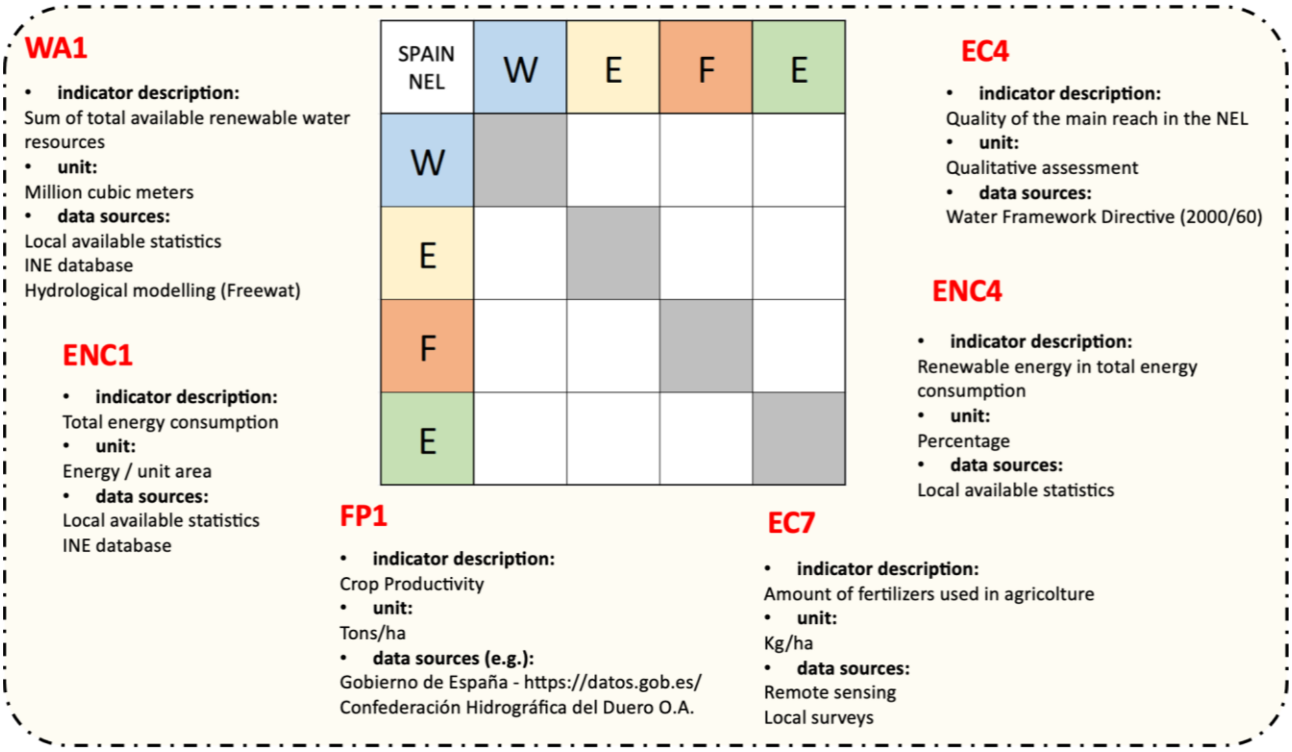


The GC2 proposed to boost the ecosystem services for sustainable management of the resources. Particularly, the development of Nature Based Solutions (NBS) can increase the water availability in the NEL (WA2). In this case, there are not so many trade-offs, as the NBS can allocate new water resources without new electricity consumption. Therefore, the ENC2 will measure the avoided energy consumption that the NEL would have spent to pump the same amount of water from the ground. This will lead to a reduction of the Total Energy Consumption (ENC1) in the NEL. For the same reason, this solution also improves the quality of the ecosystem, as it reduces CO_2 in the atmosphere (EC6) due to electrical energy production of the amount of energy that is saved thanks to the NBS. At the same time, water available thanks to NBS will also increase the blue water given in agriculture (WU4), possibly enhancing crop water productivity (FP2) and reducing groundwater over-exploitation (WU5). Also for the second grand challenge the Water for Food sub-nexus level can be evaluated with the ARTEA dataset and with the output of the Watneeds model. The avoided over-exploitation in the NEL can be evaluated with the Freewat model outputs.

3.2 SPAIN

3.2.1 WEFE Nexus Indicators at the NEL scale

The indicators necessary for the WEFE Nexus assessment at the NEL scale are reported in the following figure.



3.2.2 Grand Challenge in the Spanish NEL

Grand Challenge 1

The GC in the Spanish NEL consists in the building of resilient irrigated agriculture in depopulated areas, to face water scarcity, the rise in the prices for energy and for fertilisers, among a reduction in the food production incomes.

The study aims will be achieved through, firstly, the analysis of water and energy consumption, together with the expansion of irrigated agriculture to observe trends and relation among variables, also considering the added economic value in the irrigated area. Secondly, through the quantification at local scale, with daily or monthly time resolution, of Green and Blue water and energy consumption for the major agricultural crops. The "Watneeds" model will be used to estimate the water-energy necessities, and for further steps of the studies.

Seven indicators have been identified for the Spanish Grand Challenge. Two of them are related to the Energy sector of the Nexus, the ENC2 and the ENC5. One is related to the water sources, the WA2. Three are related to the water footprint, the WU3, the WU4 and the WQ1. Lastly, the FP2 indicator is related to food production.

The indicators are strictly related to each other and they are better detailed in the following figures.

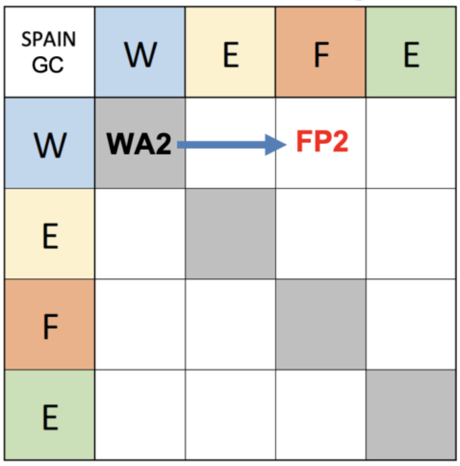
WA2

- **Indicator description:**
Total water available from non-conventional water resources, as: rainfall harvesting techniques, valorization of return flows, wastewater treatment

- **Unit:** million cubic meters

- **Data sources:**
Observations
On-site surveys
Specific studies

The water availability measured by WA2 is related to the non conventional water sources, and it will influence the indicators related to the Food sector (production) and also the Green and Blue water footprints.



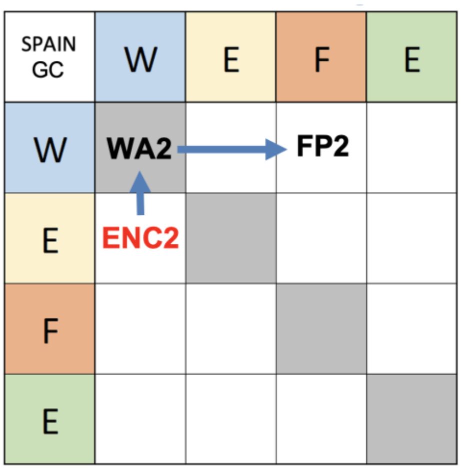
FP2

- **Indicator description:**
Tons of harvest product per unit of irrigated water.

- **Unit:** Tons/unit volume of water

- **Data sources:**
Statistics
Studies

The FP2 indicator is able to represent the relation between the irrigated area and its crop production. It is directly dependent on the water availability measured by WA2, which, among other factors, regulates the productivity of the fields.

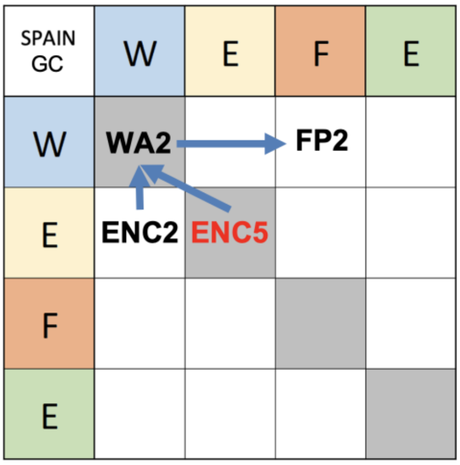


ENC2

- **Indicator description:**
Energy consumption declined by nexus sectors: Water, (Energy), Food, Ecosystems

- **Unit:** Total energy/sector

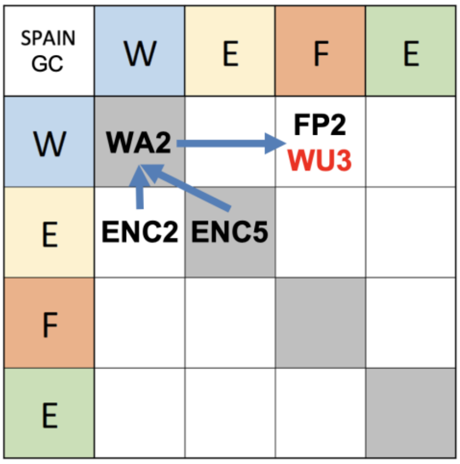
- **Data sources:**
Specific studies
Statistics



ENC5

- **Indicator description:**
Renewable energy share in total energy consumption declined into energy type: Solar, Wind, Geotherm, Biogaz, Hydropower
- **Unit:** percentage
- **Data sources:**
Case specific studies
Energy authority
Energy suppliers

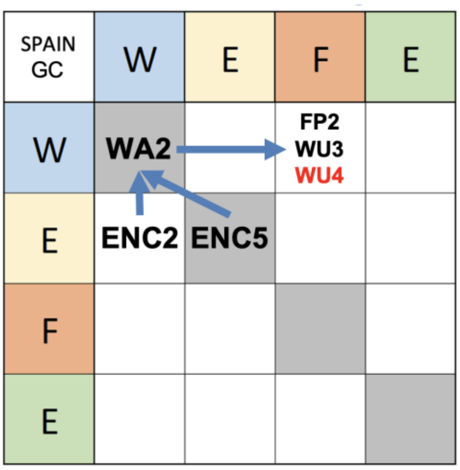
The ENC2 and ENC5 belong to the energy sector and are aimed at monitoring the energy necessities and the energy availability, declined for each Nexus sector and for each energy source, respectively. The indicator WA2 is directly influenced by these two indicators, as energy is required to retrieve water from non conventional water resources.



WU3

- **Indicator description:**
Green water footprint. Water from precipitation (rain or snow) that is stored in the root zone of the soil and evaporated, transpired or incorporated by plants
- **Unit:** volume/unit area
- **Data sources:**
Statistics
Footprints

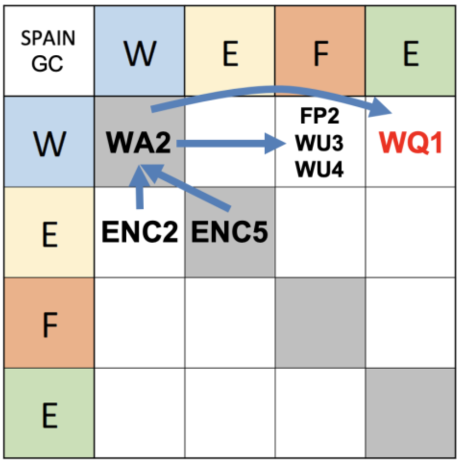
The Green water footprint indicator (WU3) is related to the climate, soil and morphologic characteristics of the watershed. It is also dependent on the crops, which have different water absorption, storage and transpiration.



WU4

- **Indicator description:**
Blue water footprint. Water that has been sourced from surface or groundwater resources and is either evaporated, incorporated into a product or tipped into the sea. Irrigated agriculture, industry and domestic water use can each have a blue water footprint.
- **Unit:** volume/unit area
- **Data sources:**
Statistics
Footprints

The WU4 indicator represents the Blue water footprint, and it is primarily dependent on the morphology and the geology of the watershed. It is also related to the crops, the land use and the climate of the basin.



WQ1

- **Indicator description:**
Grey water footprint. The amount of fresh water required to assimilate pollutants in the production process to meet water quality standards.

- **Unit:** volume/unit area

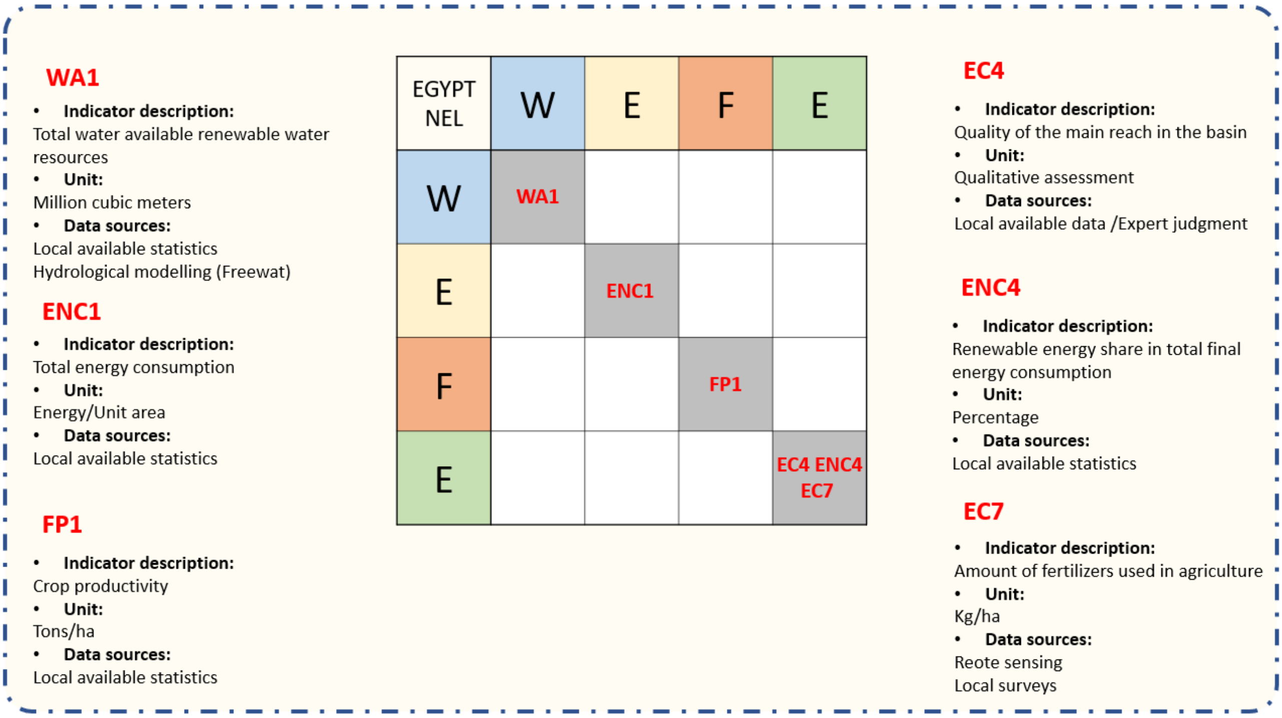
- **Data sources:**
Statistics
Footprints

The WQ1 indicator is related to the cultivation process and the pollution which is derived from it. The less pollutant the production process, the less is the amount of water necessary to dilute the pollutants and thus meet the water quality standards.

3.3 EGYPT

3.3.1 WEFE Nexus Indicators at the NEL scale

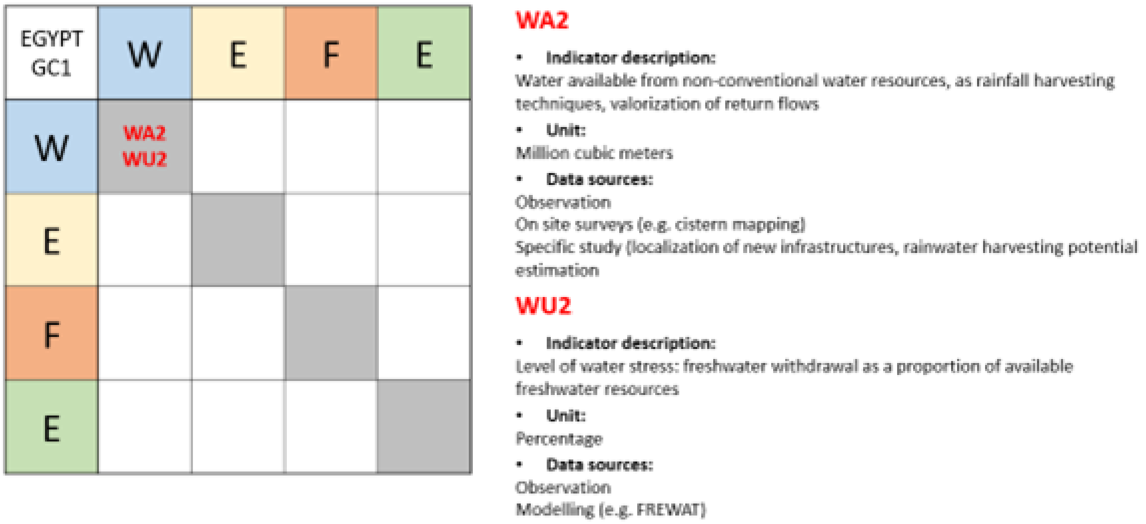
The present and potential future situation of the Egyptian NEL can be described according to the set of indicators specified in section 2.



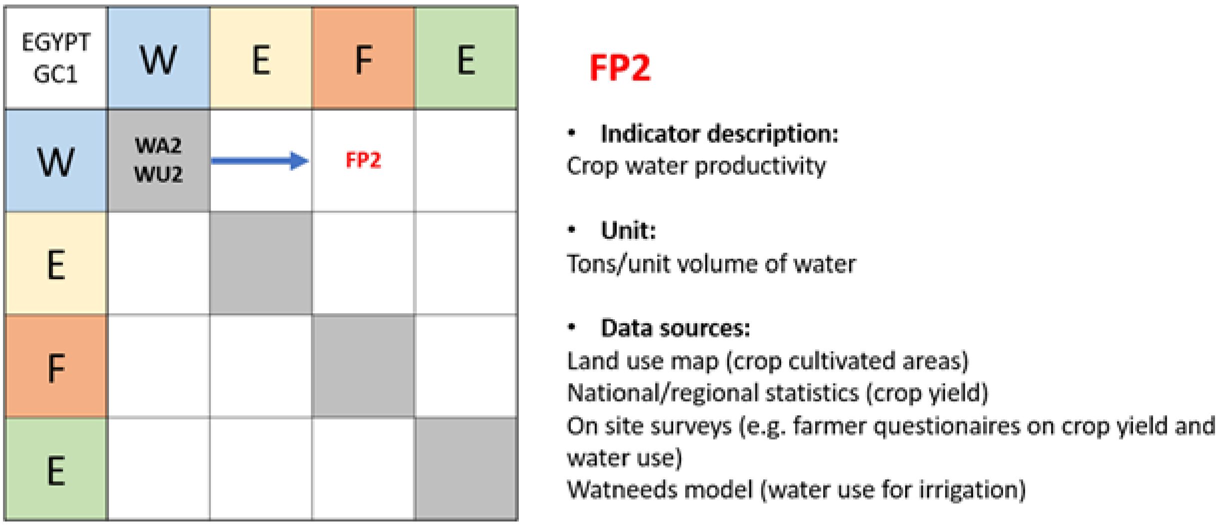
3.3.2 Grand Challenge in the Egyptian NEL

Grand Challenge 1

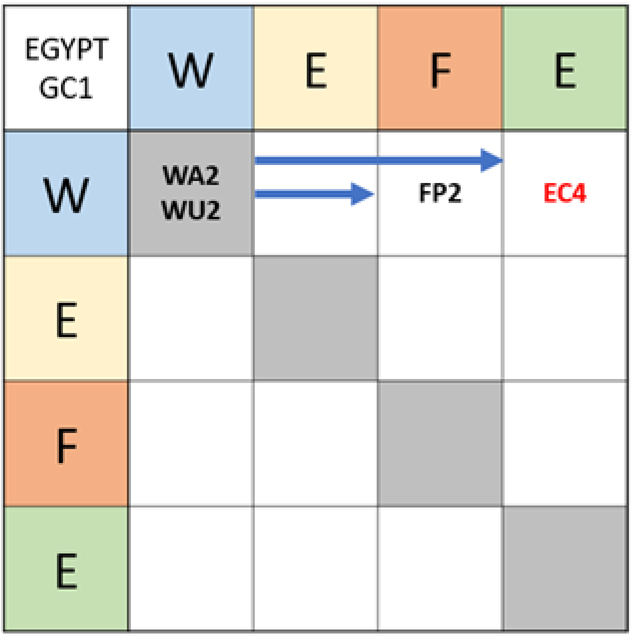
The first Nexus Grand Challenge is to set a plan for the sustainable intensification of water infrastructures in the watershed for food production, without creating water allocation imbalances. This challenge is based on the Water dimension of the Nexus that is the strategic resources needed to support a local economy mainly based on agricultural production as in the case of Wadi Nagamish. The rainfall variability inside the basin determines the necessity of implementing new water harvesting structures specially to support Bedouins families. The water dimension can be measured in terms of water availability connected to the use of non-conventional sources, using the indicator WA2 that aims at evaluating the amount of water resources that can be stored using non-conventional techniques (in particular rainfall harvesting). The increase in the non-conventional water should also have a positive impact on the level of water stress (evaluated through the indicator WU2).



The Water dimension is strictly connected to the Food dimension, with cultivation of olives, figs and barley mainly located in the central and northern part of the watershed. Aiming at describing and avoiding potential allocation imbalances the Food-Water dimension needs to be measured evaluating the green/blue water partitioning (WU3 and WU4) and the water productivity (FP2).



Also, the quality of water bodies and connected ecosystem can be positively influenced by the increase in water availability connected to the use of non-conventional water. The EC4 indicator can be used to monitor the quality of the main water bodies in the NEL.



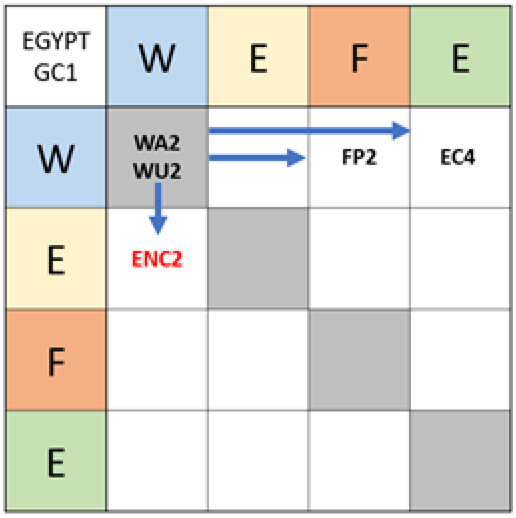
EC4

- **Indicator description:**
Quality of the main reach in the basin

- **Unit:**
Qualitative assessment

- **Data sources:**
Local available data /Expert judgment

The availability of non-conventional sources of water is also linked to the Energy dimension of the Nexus due to the extra amount of energy that is needed to sustain the new irrigation schemes. The ENC2 indicator, i.e. the energy consumption declined by nexus sectors (in this case water), can be used to evaluate the effects of using non-conventional water sources on energy demand.



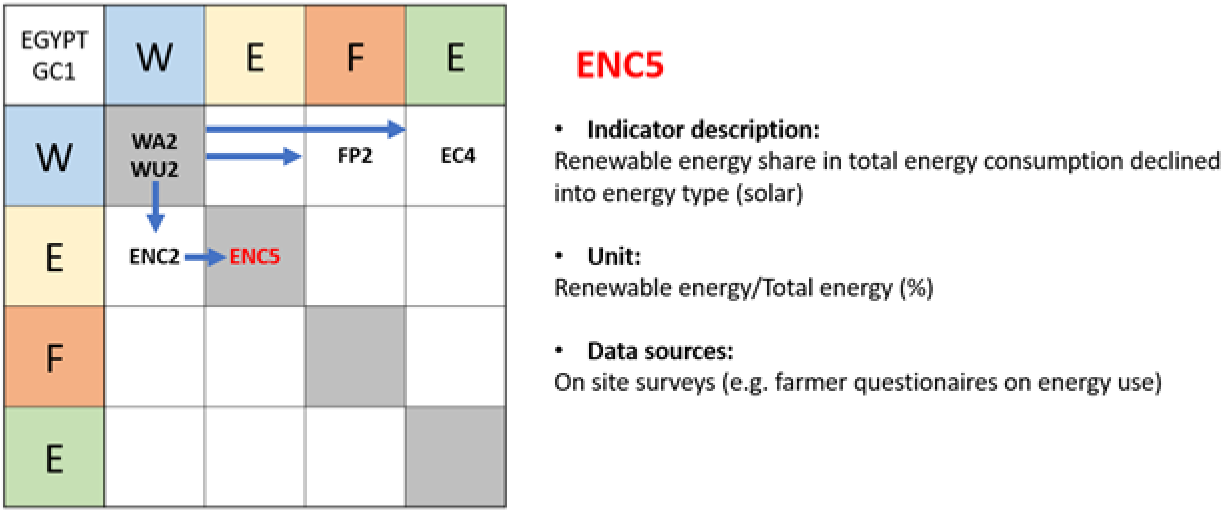
ENC2

- **Indicator description:**
Energy consumption declined by nexus sectors (energy for water)

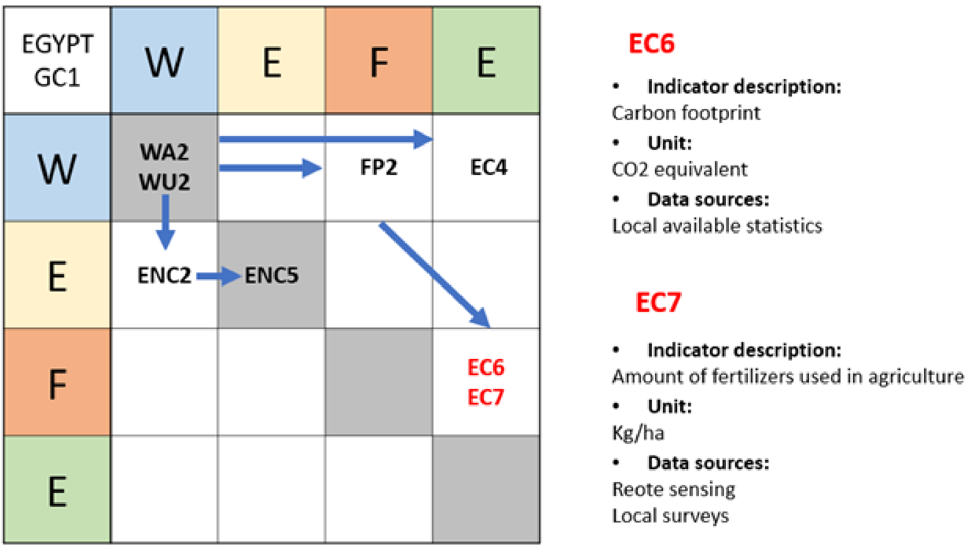
- **Unit:**
Energy/sector

- **Data sources:**
National/regional statistics (energy consumption per agricultural unit areas)
On site surveys (e.g. farmer questionaires on energy use)

Shifting from fossil fuels (currently used for pumping) to renewables has been included in the first grand challenge as a possible solution to mitigate the potential negative externalities deriving from the implementation of new irrigation schemes. Indeed, the use of renewable sources of energy is crucial to boost agricultural production while keeping a safe environment and this strategy can be monitored using the indicator ENC5 looking at estimating the renewable energy share in the total energy consumption (in the scenarios as it should be).

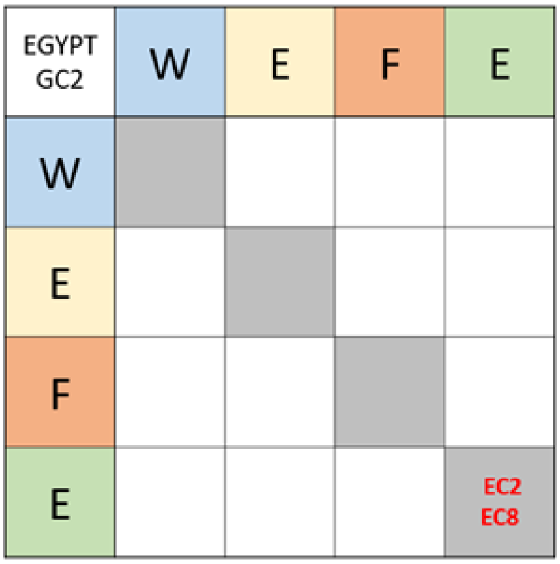


Finally, it should be considered how the increase in agricultural production driven by the use of the non-conventional sources of water can affect the ecosystem quality. In particular the agricultural sector impacts can be measured by evaluating indicators such as the environmental footprint (EC6) and the amount of fertilizers used in agriculture (EC7).



Grand Challenge 2

The second grand challenge identified by the Egyptian NEL refers to the necessity of evaluating potential issues deriving from land use change occurring within the NEL. Two main competing sectors have been identified (i.e., agriculture and tourism) whose development should accurately be evaluated and planned to assure soil conservation. Therefore, the Ecosystem dimension is the starting point to evaluate this grand challenge, introducing an indicator (EC8, not belonging to the indicators list included in deliverable 5.1) that can help understanding the share of areas with deep soils used in the NEL.The competition between tourism and agriculture resulting in land use change can also affect the Ecosystem by threatening protected areas (indicator EC2).



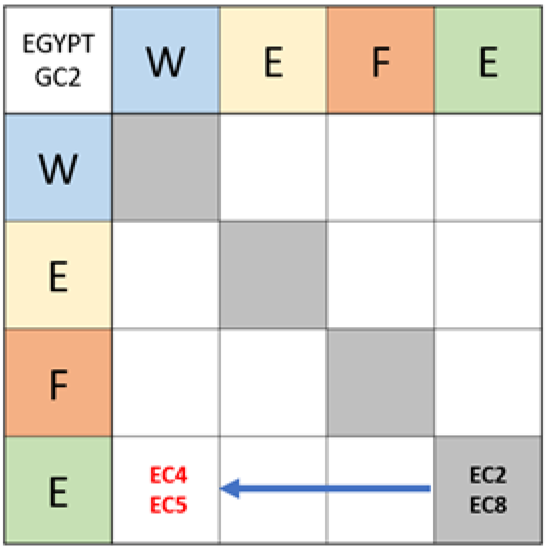
EC2

- **Indicator description:**
Share of protected areas
- **Unit:**
Percentage
- **Data sources:**
Local available data (GIS analysis on land use)

EC8

- **Indicator description:**
Share of deep soil areas in the NEL
- **Unit:**
Deep soils areas/Total areas(%)
- **Data sources:**
On site survey to evaluate soil caractheristics
Existing soil maps

The increase in agricultural areas can lead to an increase in effluent (indicator EC5) and to a potential deterioration of water quality (evaluated using the indicator EC4)



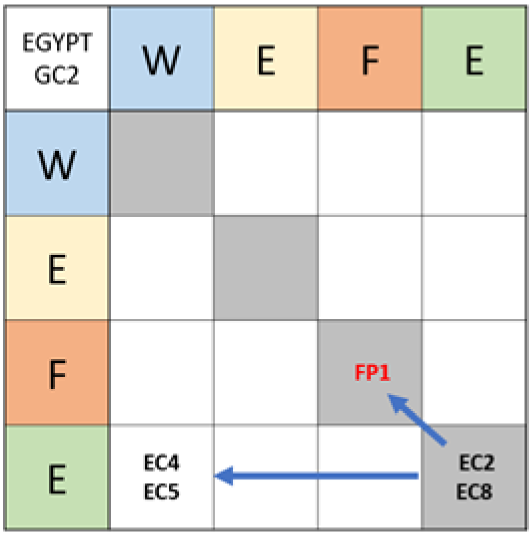
EC4

- **Indicator description:**
Quality of the main reach in the basin
- **Unit:**
Qualitative assessment
- **Data sources:**
Local available data /Expert judgment

EC5

- **Indicator description:**
Effluent processing
- **Unit:**
Score
- **Data sources:**
Local available data on how the farmer deals with the effluent

The Ecosystem dimension is strictly connected to the Food dimension that can be assessed in terms of crop productivity (FP1).



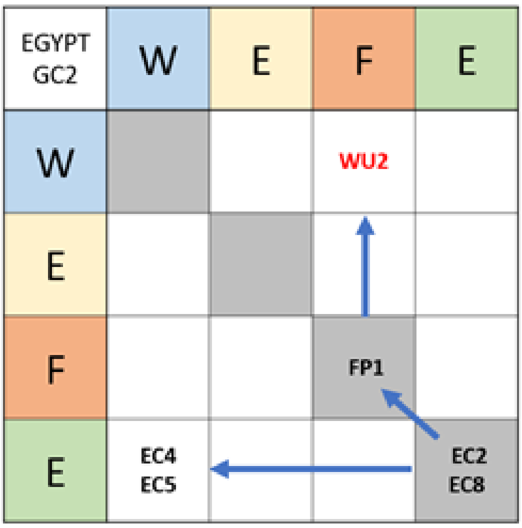
FP1

- **Indicator description:**
Crop productivity

- **Unit:**
Tons/ha

- **Data sources:**
Local available statistics
Survey (stakeholders questionnaires)

The evolution in the agricultural sector can have an impact on the water dimension, determining an increase in stress on fresh water given the need for more water for agricultural production. The indicator WU2 can be used to evaluate the water resources status.



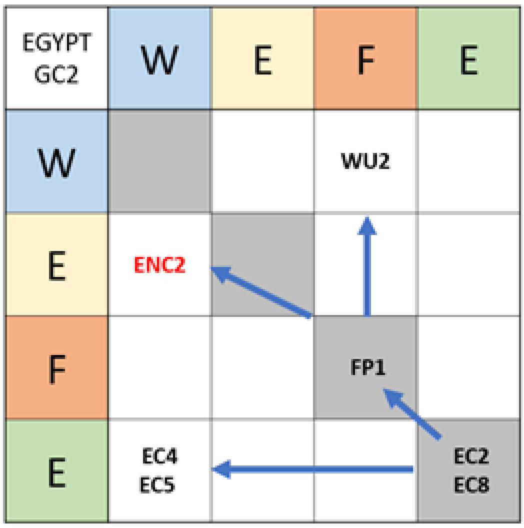
WU2

- **Indicator description:**
Level of water stress: freshwater withdrawal as a proportion of available freshwater resources

- **Unit:**
Percentage

- **Data sources:**
Observation
Modelling (e.g. FREWAT)

Finally, the energy sector can also be impacted given the need to pump more water for a larger agricultural sector (this aspect can be evaluated using the indicator ENC2).



ENC2

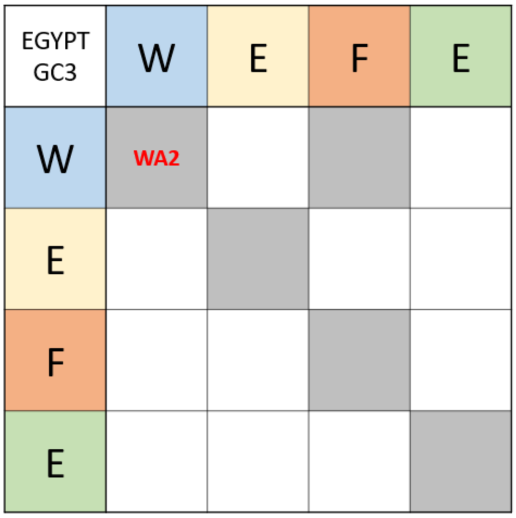
- **Indicator description:**
Energy consumption declined by nexus sectors (energy for water)

- **Unit:**
Energy/sector

- **Data sources:**
National/regional statistics (energy consumption per agricultural unit areas)
On site surveys (e.g. farmer questionaires on energy use)

Grand Challenge 3

The third grand challenge is related to the use of desalinated water and wastewater reuse to mitigate water scarcity issues in the NEL. As for the grand challenge 1, also in this case the Water dimension is pivotal and can be measured using the indicator WA2.



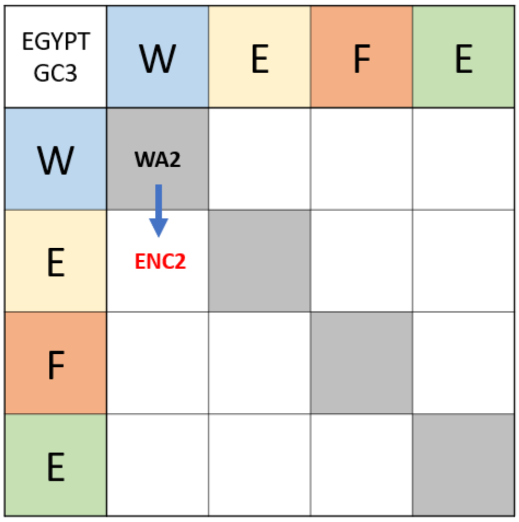
WA2

- **Indicator description:**
Water available from non-conventional water resources, as desalinization and wasterwater reuse

- **Unit:**
Million cubic meters

- **Data sources:**
Specific study estimating desalinization and wastewater reuse potential

The use of desalinated water and wastewater is strongly dependent on the energy availability to allow the proper treatments. The Energy dimension can be assessed using the indicator ENC2.



ENC2

- **Indicator description:**

Energy consumption declined by nexus sectors (energy for water)

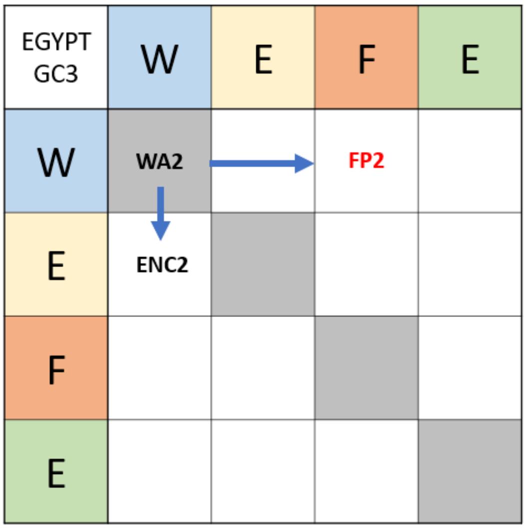
- **Unit:**

Energy/sector

- **Data sources:**

On site surveys (e.g. wastewater treatment plant energy use evaluation)
Existing literature in desalinization energy consumption

Also in this case the use of water is mainly oriented to agriculture, therefore the Food dimension should be evaluated using indicators FP2.



FP2

- **Indicator description:**

Crop water productivity

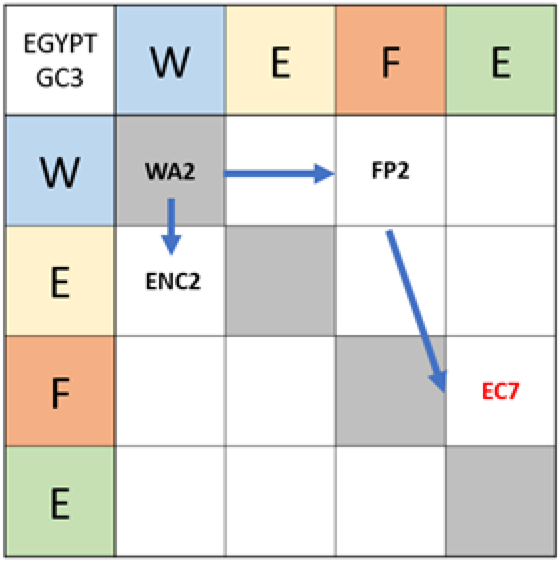
- **Unit:**

Tons/unit volume of water

- **Data sources:**

Land use map (crop cultivated areas)
National/regional statistics (crop yield)
On site surveys (e.g. farmer questionnaires on crop yield and water use)
Watneeds model (water use for irrigation)

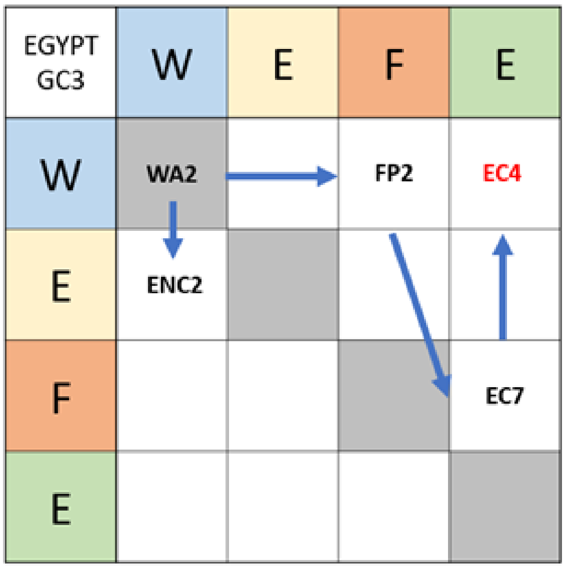
The potential use of treated wastewater for irrigation can influence the quality of ecosystems determining a reduction in the amount of fertilizer needed (measured using indicator EC7).



EC7

- **Indicator description:**
Amount of fertilizers used in agriculture
- **Unit:**
Kg/ha
- **Data sources:**
Remote sensing
Local surveys

Finally, this can lead also to an improvement of the water quality in the water bodies (assessed through the indicator EC4).



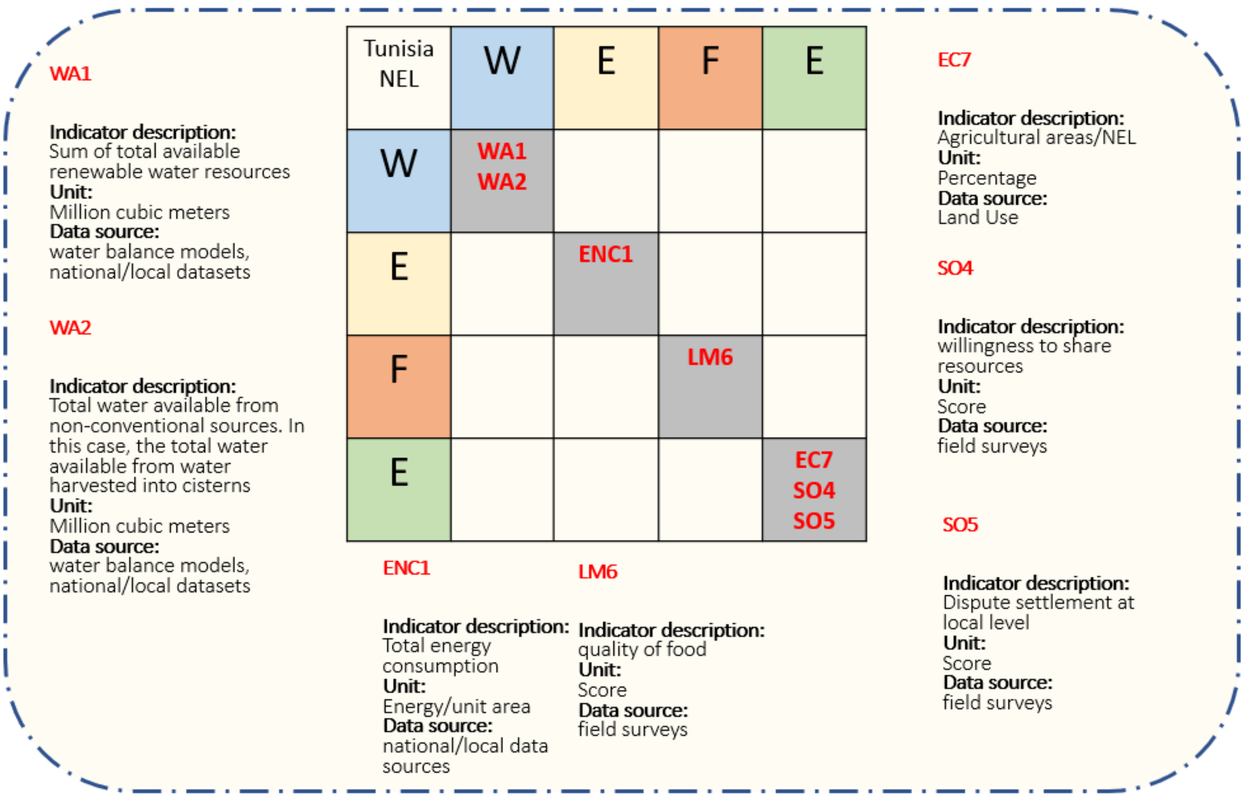
EC4

- **Indicator description:**
Quality of the main reach in the basin
- **Unit:**
Qualitative assessment
- **Data sources:**
Local available data /Expert judgment

3.4 TUNISIA

3.4.1 WEFE Nexus Indicators at the NEL scale

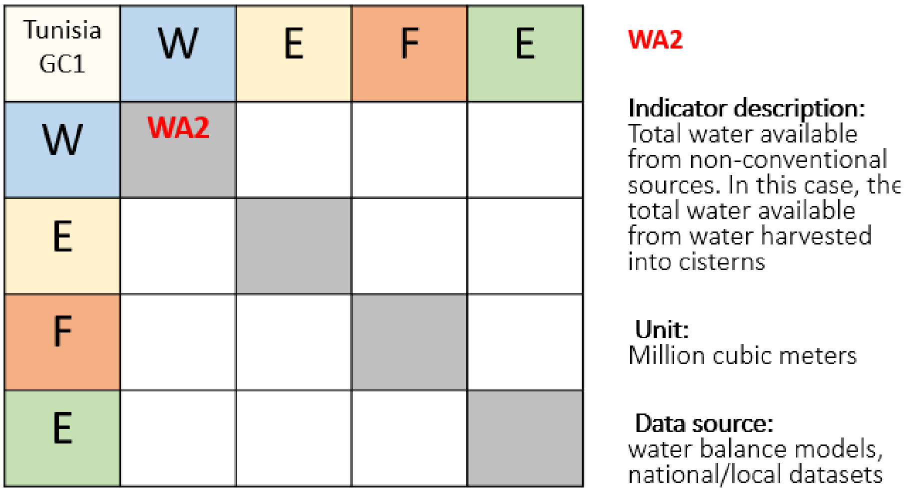
The Tunisian NEL can be characterised primarily as an agricultural landscape, mainly managed by families. An essential challenge for the agricultural watershed is the upstream-downstream disparity induced by anthropogenic interventions and management schemes developed. The major flood diversion canal and the presence of multiple check dams used for irrigation, focalize the current nexus solutions on the water sector implementation for agriculture. The following presents the three identified grand challenges, their suggested indicator assessment, and a look at the potential implication of future scenarios on the assessed indicators. The "as it is" scenario can be represented within the following matrix



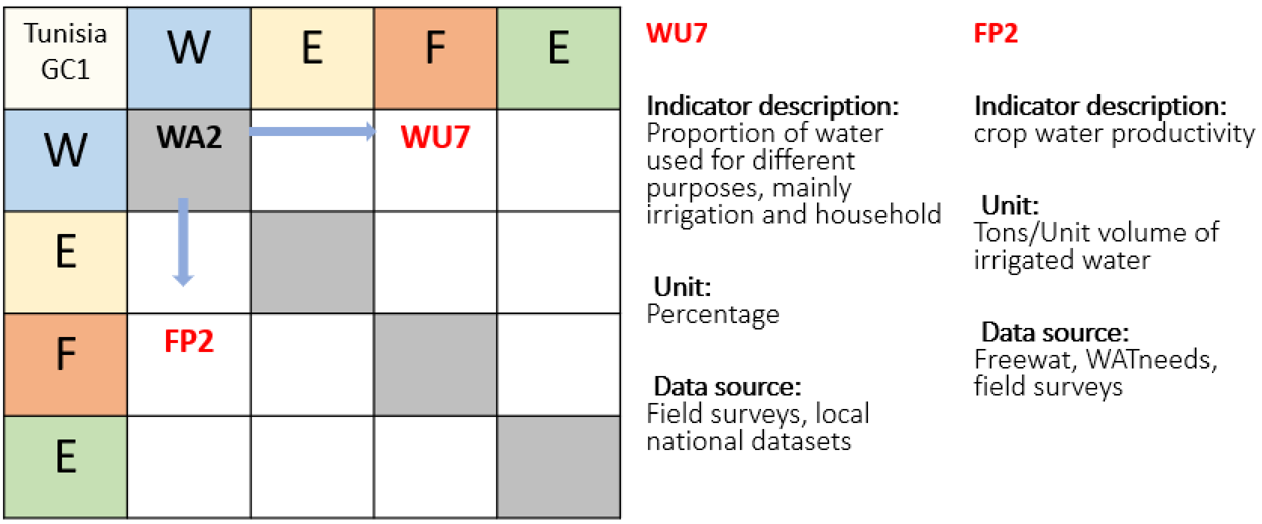
3.4.2 Grand Challenge in the Tunisian NEL

Grand Challenge 1: Best water and crop allocation strategy

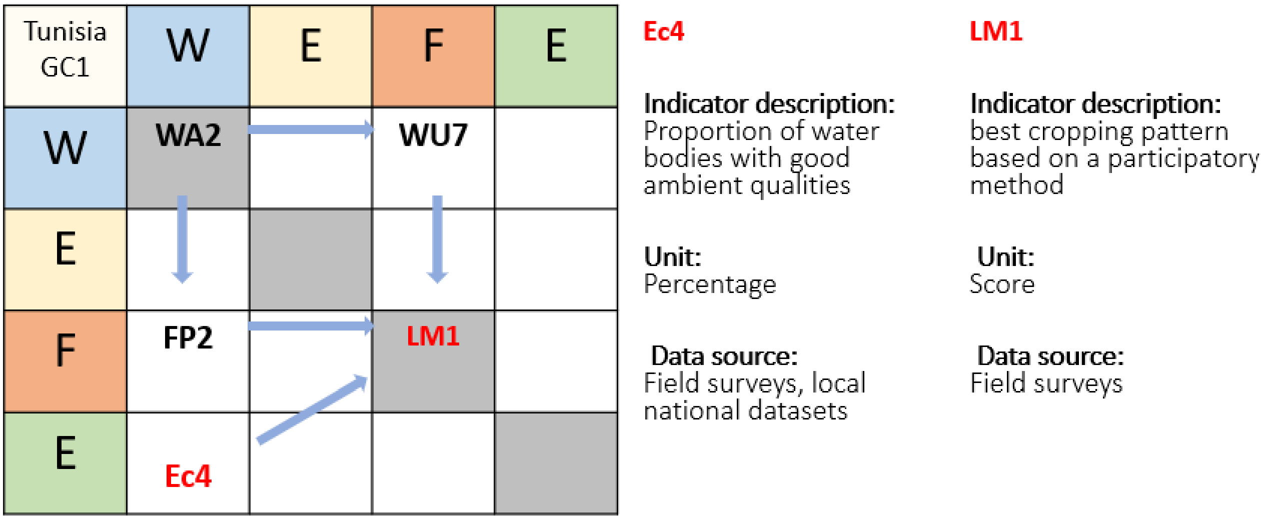
With a total population of 18,000 km2, consisting mainly of agriculture families, the tunisian NEL currently relies on the plantations of Olives,cereals, with surface rainwater being harvested in cisterns, on an individual level, while the flooded diverted water serves for groundwater recharge and is publicly managed. Hence, from a practical point of view, the nexus indicator assessment can start from WA2 (Total available water from "non-conventional" techniques). The main idea behind the first grand challenge is to render the farming practices in the NEL a profitable business and reduce seasonal migration from inhabitants to search for other job opportunities.



The total amount of water available is mainly used for irrigation and household use, hence it translates into the following indicator WU7 for food (crop production) . This water used for irrigation is interchangeably connected to the crop water productivity that is affected by both biophysical and anthropogenic constraints



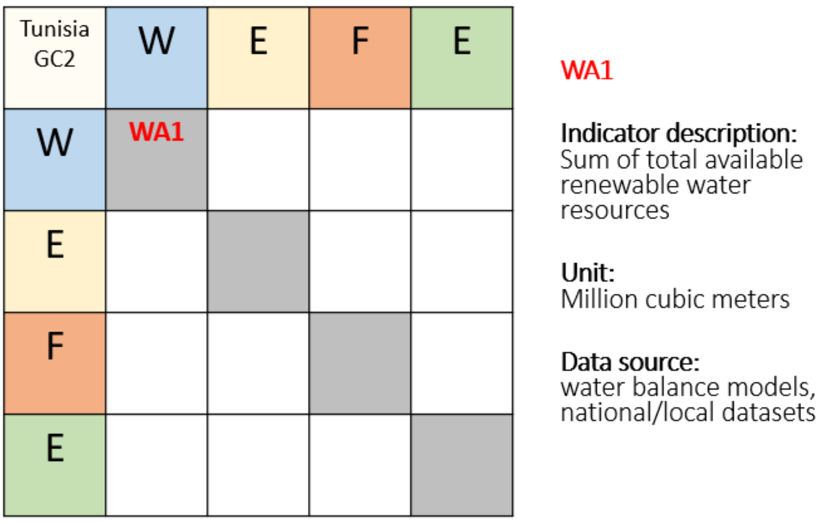
Keeping the purpose of the 1st grand challenge in mind, the choice of the best cropping pattern can be represented by LM1 (land management 1); a highly participatory indicator that defines the best cropping pattern. Given its focus on crop production, this is assigned the F-F and fed directly from the water indicators. An additional constraint is put by the quality of the water in the ecosystem that can be represented as EC4 (proportion of water bodies with good ambient quality)



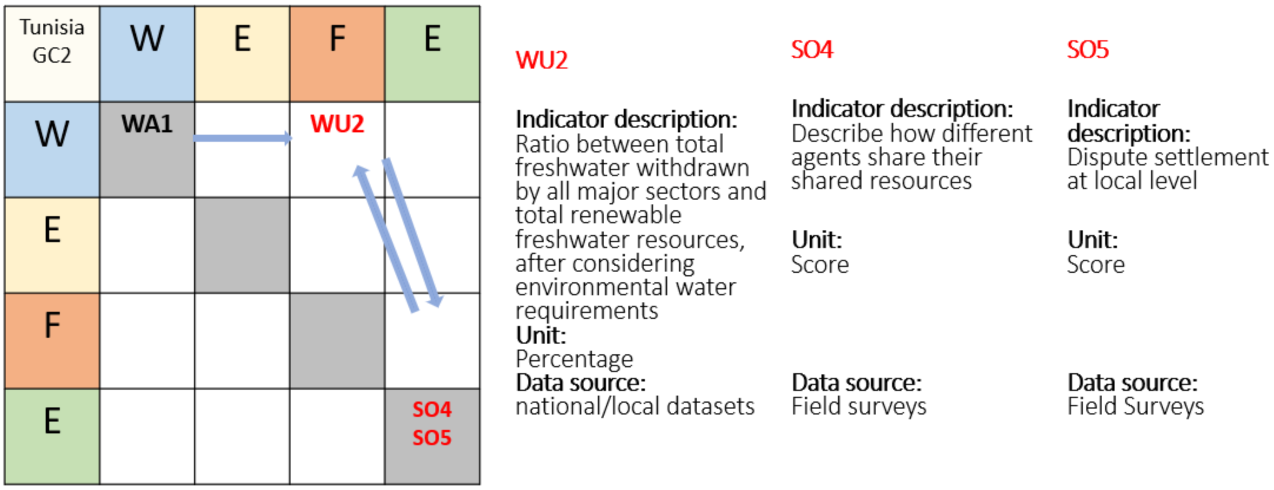
Given the reliance on energy imports in the NEL, little action can be taken concerning the allocation of energy related indicators that highly affect the best cropping strategy.

Grand Challenge 2: Management of the check dams and upstream-downstream disparity

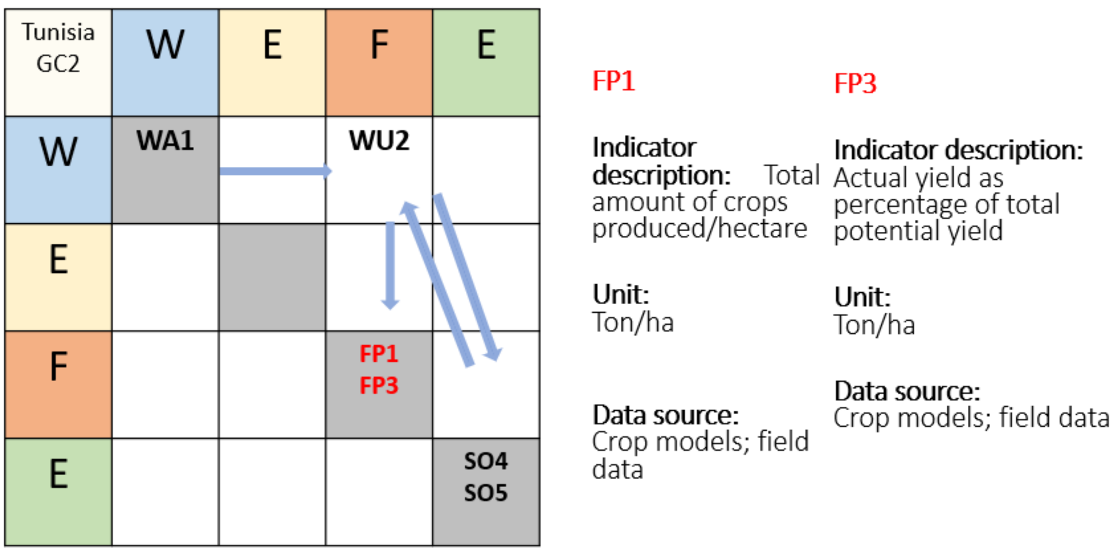
The disparity created between upstream and downstream areas in the NEL is related to the distribution of water collected from the check dams and the flood diversion. This can be represented with the indicator WA1 (Total available renewable water resources).



Starting from the availability of water represented by the WA1 indicator, we look at the different levels of water withdrawal at each check dam and by each user at the status quo, and especially for irrigation. This can be represented by WU2 (level of water stress). This is also related to the degree of farmers' organisation and their willingness to manage shared resources and settle expected disputes (SO4,SO5).

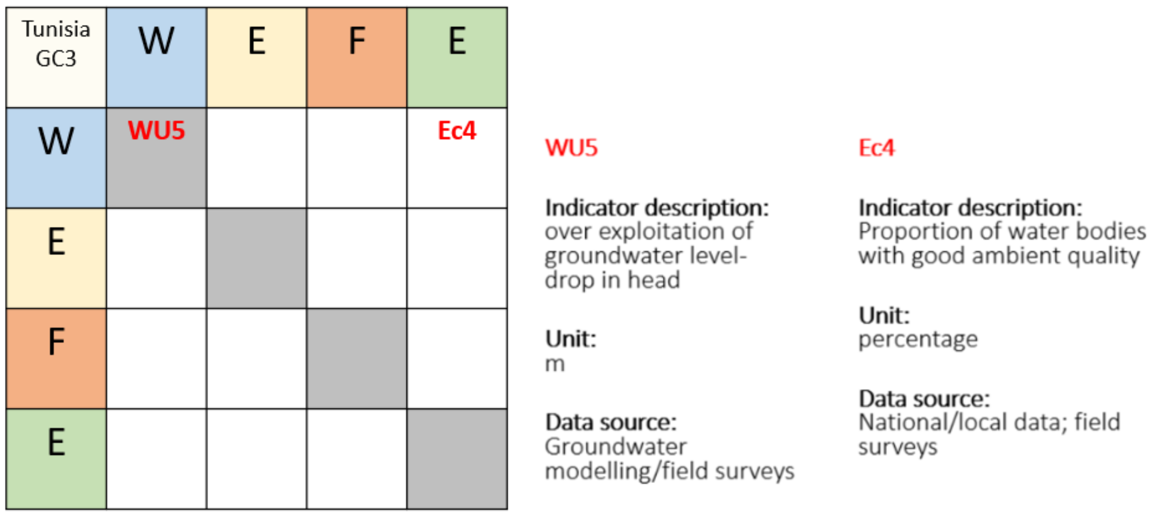


In addition, an environmental requirement exists with the check dams, concerning a minimum environmental flow, sizing, and operation scheme. Moreover, given that the silted material is used as soil for plantations, changing the volumes and operation of these dams could possibly affect the crop yield. Hence, the final link for the second grand challenge would be optimising water distribution from the check dams (represented by WU2), ensuring a good cooperation (SO4 and SO5), and providing crop yield viable for sustaining the farming practices and businesses.

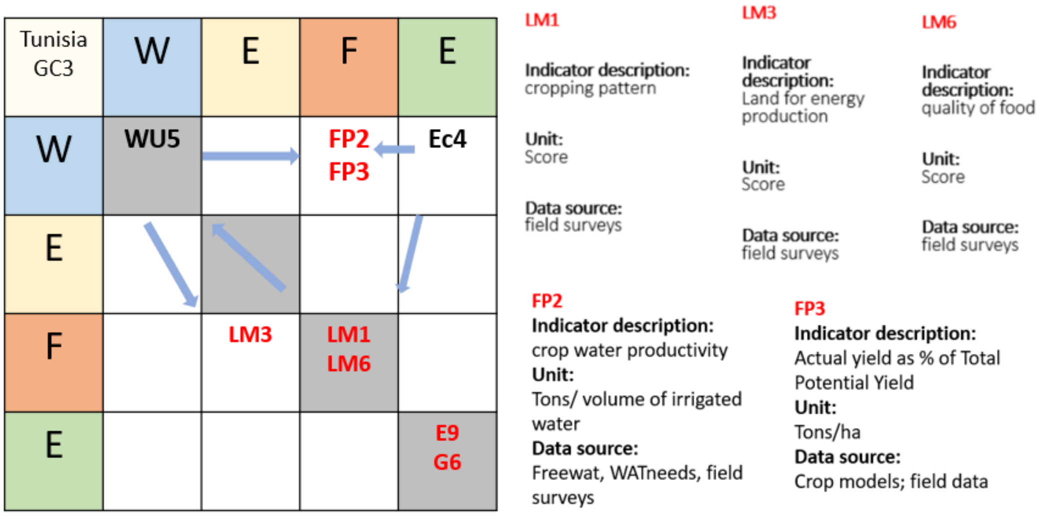


Grand challenge 3: impact of changes in groundwater recharge on local resources

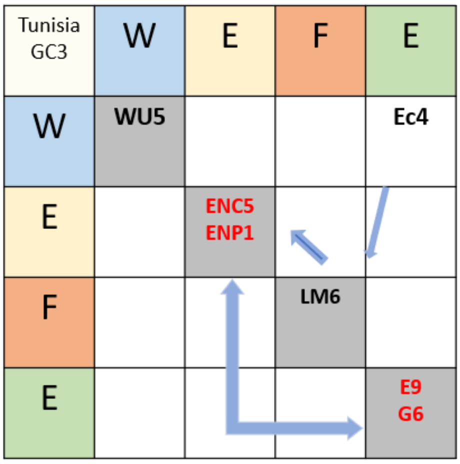
Groundwater recharge is performed through the flood diversion intervention built downstream. Being publicly managed, a real participatory distribution scheme is not present. This is being accompanied with increasing salinity of the groundwater table due to seawater intrusion. Hence, the initial possible solution to address the economic impact due to the damage of such intrusion would be to ensure a resilient cropping pattern (LM1) and taking advantage of future renewable energy programs planned on a national level to produce energy and reduce the energy expenditure (LM3). The initial starting point is to assess possible over exploitation of the groundwater bodies by the agricultural users (WU5), ensuring that no excess water is being used based on the proportion of water bodies with good ambient water quality (Ec4).



The increase in salinity is expected to affect both crop water productivity (FP2) , and the yield gap (FP3) while leading to a decrease in the quality of the food produced (LM6). Besides the yield variable, the quality of the crop produced holds a major economic and societal value, which justifies the inclusion on LM6.



In case renewable energy is seen as a gateway to compensate for economic losses induced by the groundwater salinity and management situation, both renewable energy consumption and production come in hand. The consumption of renewable energy can be attributed only to the agriculture sector, given that nationally centralised household electricity distribution, which plays a factor in hindering a total reliance on renewable energies. This consumption can be represented by ENC5 (the total renewable energy share in total energy consumption). Production is to be done mainly by solar panels, hence the energy produced via land sharing (or ENP1) is a representative indicator. The feasibility of such application technically relies on the economic benefit as income (E9) and the required environmental constraints and impact assessment (G6)



ENC5

Indicator description: renewable energy share in total energy consumption

Unit: Total Energy/ sector

Data source: national/local data sources

ENP1

Indicator description: energy via land sharing/solar panel

Unit: KJ

Data source: national/local data sources

E9

Indicator description: net income from energy production

Unit: Monetary unit

Data source: national/local data sources

G6

Indicator description: Environmental impact assessment

Unit: Score

Data source: Field survey; analysis

4. Conclusion

This first release of the deliverable represents a preliminary selection of indicators that need to be validated within the NELs whose feedback will be fundamental to improve the representativeness of the chosen indicators. Indeed, a participatory approach that involves the NELs leaders and stakeholders is essential for defining the lists of indicators. This is even more necessary since the grand challenges can undergo some changes during the NEL workshops and therefore continuous feedback from the NEL is needed. In addition, the data required for the computation of the indicators require a close cooperation with the NELs leaders in order to ensure data availability or data collection for certain data types that require local surveys. Such cooperation can surely be achieved through the meetings and workshops organised within WP2. Similarly, a close cooperation is needed with WP4 for the models’ outputs since a lot of indicators are dependent on these outputs.

Moreover, the matrix representation utilized in this deliverable can support the cost-benefit assessment of different possible WEFE nexus transition paths (WP5).

The selected indicators presented in this deliverable are covering all the WEFE dimensions in the four NELs (i.e. Water, Energy, Food and Ecosystems). However, additional consideration on the socio-economic impacts of different WEFE Nexus transitions paths can be included using the sociological, ecological and governance indicators available in the indicators catalogue proposed in D5.1. The gender dimension should be also taken into account in accordance with the deliverable D2.3. Similarly, the potential source of data to populate the indicators can be integrated and updated in the following releases of the deliverable (Month 24 and 30).