LEarning and action alliances for NexuS EnvironmentS
in an uncertain future

LENSES

WP4

D4.1.2 Report on Participatory Social Mapping and Social Network Analysis. Identification of Domain Objectives, Nexus Resilience Qualities and Nexus Indicators – Revised Volume

Mert Can Gunacti (EA-TEK), Cem Polat Cetinkaya (EA-TEK), Alessandro Pagano (IRSA), Ali Gul (EA-TEK), Raffaele Giordano (IRSA), Gulay Onusluel Gul (EA-TEK), Filiz Barbaros (EA-TEK), Sefa Nur Yeşilyurt (EA-TEK), Ivan Portoghese (IRSA), Estrella López Moya (ECOADAPTA), Andreas Panagopoulos (SWRI), Vassilios Pisinaras (SWRI), Nikolaos Nikolaidis (TUC), Silvia Vanino (CREA), Nabeel Bani Hani (NARC), Idan Kopler (MIGAL), Zubeyde Albayram Dogan (UTAEM)

30/11/2023

Project coordinator

Project partners

Project Website

www.lenses-prima.eu

This project is part of the PRIMA programme supported by the European Union.
GA n° [2041] [LENSES] [Call 2020 Section 1 Nexus IA]

Project no.	2041
Project acronym:	LENSES
Project title:	Learning and action alliances for NEXUS environments in an uncertain future
Call:	PRIMA call Section 1 – Nexus 2020, Topic 1.4.1-2020 (IA).
Start date of project:	01.05.2021
Duration:	36 months
Deliverable title:	D4.1 Report on PSM and SNA. Identification of DOs, NRQs and NIs
Due date of deliverable:	November 2023
Project Coordinator:	Stefano Fabiani, Council for Agricultural Research and Economics (CREA)

Organisation name of lead contractor for this deliverable: EA-TEK (LEAD PARTNER)

Lead Authors	Mert Can Gunacti (EA-TEK), Cem Polat Cetinkaya (EA-TEK), Alessandro Pagano (IRSA), Ali Gul (EA-TEK), Raffaele Giordano (IRSA), Gulay Onusluel Gul (EA-TEK), Filiz Barbaros (EA-TEK), Sefa Nur Yeşilyurt (EA-TEK), Ivan Portoghese (IRSA)
Email	mert.gunacti@deu.edu.tr, cem.cetinkaya@deu.edu.tr, alessandro.pagano@ba.irsa.cnr.it, raffaele.giordano@cnr.it
Contributions from	IRSA, ECOADAPTA, SWRI, CREA, TUC, NARC, MIGAL, UTAEM
Internal Reviewer 1	Stefano Fabiani (CREA)
Internal Reviewer 2	

Dissemination level		
PU	**Public**	**PU**
CO	**Confidential, restricted under conditions set out in Model Grant Agreement**	
CI	**Classified, information as referred to in Commission Decision 2001/844/EC**	

History			
Version	**Date**	**Reason**	**Revised by**
01	20/11/2023	Internal review	Stefano Fabiani
02	25/11/2023	Revised version	

This project is part of the PRIMA programme supported by the European Union.
GA n° [2041] [LENSES] [Call 2020 Section 1 Nexus IA]

Executive summary

The present deliverable is an extension of previous D 4.1 submitted on 30/04/2022 and aims to update the methodological approach description that has been used in LENSES to analyze how the complex set of interactions between biophysical resources and multiple agents involved in their use/management could be understood and used to capture the impact of Nexus management strategies. As noted in the previous version of the deliverable, a clear identification of the main challenges and of strategic objectives for the pilot areas are described, and 'system' qualities have been assessed to describe system state and evolution. The developed methodological approach to support an improved conceptual understanding of Nexus systems has been identified to model the role of potential barriers and management actions. Regarding the first point, this Deliverable presents the identified indicators by the pilots with the help of the inventory list provided in previous version. Furthermore the selection of certain indicators is based on the Domain Objectives (DOs, which require determining the current situation and its evolution in time) proposed Nexus Indicators (NIs) and Nexus Resilience Qualities (NRQs) which provide foundation to resilient and adaptive Nexus structures. Regarding the latter point, the present work presents some outcomes of the approach applied for the analysis of interactions among the different socio-economic and institutional actors, as well as among ecological resources and processes affecting the production of Ecosystem Services (ES). Taking advantage of Participatory Social Mapping exercises and Social Network Analysis, qualitative and in some extent quantitative SDM tools (Causal Loop Diagrams – CLDs, and stock and flow analysis in some pilots) some of valuable indicators for pilots are also obtained and the current state of Nexus systems assessment has been realized. Moreover, these indicators are also evaluated under the effect of potential evolution in different scenarios.

The present Deliverable details the activities performed after the 1st project year and it is a revised version of the Deliverable 4.1.

This project is part of the PRIMA programme supported by the European Union.
GA n° [2041] [LENSES] [Call 2020 Section 1 Nexus IA]

Table of Contents

This project is part of the PRIMA programme supported by the European Union.
GA n° [2041] [LENSES] [Call 2020 Section 1 Nexus IA]

List of figures

List of tables

List of main abbreviations

CLD	Causal Loop Diagram
DOs	Domain Objectives
ESs	Ecosystem Services
LAAs	Learning and Action Alliances
NIs	Nexus Indicators
NRQs	Nexus Resilience Qualities
PSDM	Participatory System Dynamics Modelling
SNA	Social Network Analysis
WEF	Water-Ecosystem-Food (Nexus)

Report on Participatory Social Mapping (PSM) and Social Network Analysis (SNA). Identification of Domain Objectives (DOs), Nexus Resilience Qualities (NRQs) and Nexus Indicators (NIs)

1. Background and key concepts

Addressing complex environmental issues requires a clear understanding of the system structure and of the mutual interactions between the natural system and the socio-economic system which have been, to date, largely been considered in isolation from each other (Dee et. al., 2017). Social Network Analysis (SNA) and Participatory Social Mapping (PSM) have been frequently adopted to analyse the interactions among institutional and non-institutional actors to detect barriers hampering effective collaboration in decision-making (e.g. Calliari et al., 2019; Giordano et al., 2021), but neglecting the interdependencies between the social and ecological systems. LENSES aims to develop an innovative approach in this direction through the development, based on the use of Participatory System Dynamics Modelling (PSDM) techniques, of **a socio-ecological network analysis** centred on the analysis of the resources security and the flow of ESs:

- Analysing the ecological network helps identify critical dependencies that affect the state of natural resources and, as an effect, the production of ecosystem services (ES).
- The social network can specify who benefits from an ES, which entities manage the services, and how those individuals and organizations interact.

The use of participatory exercises supporting SDM building and analysis is fundamental as it helps shedding light on the interconnections and interdependencies (which are often hidden to policy- and decision-makers) that affect resources use and management.

LENSES also aims to overcome the degradation of natural resources and the pressures of population growth, industrialization, and climate challenges experienced in the pilot areas. To that end, envisioning of the goals is essential. Defining the objectives of the local communities to realize their desired future requires the representation of each stakeholder in the community. While the goals of the communities may vary internally, they can be categorized by the domains they represent in the Nexus, i.e. **Domain Objectives (DO)**, where they interact with each other. The Water – Ecosystem – Food (WEF) Nexus environments defined in the LENSES at the agricultural community and pilot extent, interact not only with these domains but also with Energy, Socio-Economy, Climate Change and Gender Equality domains.

Realizing the DOs requires not only the ambition of the community itself but also a supporting environment with socio-economic and legislative infrastructure where the Nexus environment can be built on and thrive. The elements of such an environment defines the **Nexus Resilience Qualities (NRQs),** which indicates the adaptive capacity of the local communities. Resilience reflects the ability of people, communities, societies and cultures to live and develop with change (Folke, 2016). Resilience is a dynamic concept concerned with navigating through complexity, uncertainty and change across levels and scales (Cumming et al., 2013). The concept of adaptation is closely associated with the concepts of vulnerability and adaptive capacity (Simane et al., 2014). Adaptation refers to the process, action or outcome in a system that helps to better cope with, manage or adjust to some changing conditions, stress or opportunity (Smit & Wandel, 2006). Adaptation is a manifestation of adaptive capacity that is inherent in a system and represents the ways of reducing vulnerability (Engle, 2011). In order to assess the succession of the mentioned DOs and development of NRQs, LENSES adopts an indicator-based evaluation. Indicator-based evaluation serves not only to understand the status and ongoing trends, but also to assess the results of particular management approaches and practices (Harmancioglu, 2004; Guimarães and Magrini, 2008; Walmsley, 2002). Therefore, a wide set of indicators representing each Nexus domain, i.e. **Nexus Indicators (NIs)** should be investigated.

LENSES will use the evidence of the PSDM exercises in direct connection with the DOs, NIs and NRQs. On the one hand, this will support a better identification and selection of key indicators for pilot areas (which will be directly related to the key challenges and goals for the site). On the other hand, the use of the mentioned modelling approaches, which help to assess the current state of Nexus systems and to analyse their potential evolution in multiple scenarios explicitly accounting for the stakeholders' knowledge and problem perception. Details on the methodological approach for PSDM development in pilots and on the results from PSDM implementation have been included in the D4.2.

2. Purpose of the deliverable

The present deliverable details the activities performed mainly within Task 4.1, but in tight cooperation with WP3 and the WP2 Learning and Action Alliances. The information collected and analyzed throughout project duration are updated in this revised version.

The main aim of the deliverable is to analyze and reveal how the complex set of interactions (both formal and informal) between different stakeholders and decision-makers involved in Nexus management could affect the Nexus implementation in pilots along with the interconnections and interdependencies among natural resources. Particular attention is given on the one hand to the main challenges and strategic objectives for the pilot areas (identified through the selection of indicators from available inventory as detailed in the following sections), and on the other hand to an improved conceptual understanding of Nexus systems, oriented to the detection and analysis of potential barriers to the Nexus sustainable management and to Nexus resilience enhancement. From the methodological point of view, the approach proposed in the present deliverable is oriented to the description of the complex web of interactions among different socio-economic and institutional actors, as well as among ecological resources and processes affecting the production of Ecosystem Services (ES) for the achievement of Nexus objectives and for a Nexus sustainable management. Taking advantage of Participatory Social Mapping exercises and Social Network Analysis, qualitative and in some extent quantitative SDM tools (Causal Loop Diagrams – CLDs, and stock and flow analysis in some pilots) some of valuable indicators for pilots are also obtained and the current state of Nexus systems assessment has been realized. Moreover, these indicators are also evaluated under the effect of potential evolution in different scenarios.

The report also aims to identify the Domain Objectives (DOs) of the WEF Nexus engaged at the pilot areas, in order to understand and improve the status of the defined domains. Addressing the DOs requires determining the current situation and its evolution in time; hence, the Nexus Indicators (NIs) observed are obtained in the deliverable for each pilot area. Improvement of the DOs also requires both the already established and the newly generated institutional and legislative directive frames to guide and enforce the communities that are actively participating in the local WEF environment. The related governmental and non-governmental (NGO) institutions, socio-economic and legislative infrastructure and implementation directives of public, regulations, etc. collectively define the Nexus Resilience Qualities (NRQs). NRQs provide foundation to resilient and adaptive Nexus structures. The identified qualities are defined by pilot leaders through a participatory approach and their effects to the resilience of existing systems are reasoned in the deliverable.

3. PSM and SNA for the Nexus Sustainable management

This part of the activities in Task 4.1 contributed to the detection and analysis of potential barriers to the Nexus sustainable management and resilience accounting for the complex web of interactions among different socio-economic and institutional actors, and the ecological resources and processes affecting the production of ESs for the achievement of the Nexus objectives. The key assumption here is that the different forms of interaction amongst socio-economic and institutional actors impact the production and provision of ESs and, in doing this, affect the effectiveness of the Nexus sustainable management (Weitz et al., 2017).

In order to reduce conflicts and to strengthen the synergies among different sectors, the Nexus should be governed with the focus on the interactions between policy fields and not on policy fields in isolation (Pahl-Wostl, 2019). The focus on trade-offs and synergies analysis for the sustainable management of the Nexus puts forward a system perspective and emphasizes the role of ESs as a way to operationalize it. The ES approach: i) tries to capture the nexus interactions and governance deficits by analyzing actors-ES network, ii) encourages negotiation and cooperation among ESs users, iii) supports the integration of fragmented institutional settings, iv) contributes to operationalizing the nexus in terms of trade-offs and synergies, v) and facilitates the alignment between the governance framework and the ecological processes. Adopting an ES-based approach in the analysis of the socio-economic and institutional interactions means that actors are not linked exclusively through formal interactions. Informal - and often hidden - interactions happen in the biophysical system, e.g. using the same resources or competing for the ESs.

The socio-ecological network is centered on the ESs of interest and, in a first step, uses ecological networks to identify which ecological resources and processes, directly and indirectly, contribute to the ES production and provision. In the ecological network, the nodes represent the ecological components - e.g. resources, species, etc. - and links describe the processes happening within the ecological network. The ecological network helps identify critical dependencies that affect ESs. As a second step, the social network can specify who benefits from an ES, which entities manage the services, and how those individuals and organizations interact. Stakeholders and decision-makers are indeed described in their mutual interactions, as well as with their interactions with the ecological resources needed for the ESs production. Moreover, social interactions influence knowledge exchange between different stakeholders involved in decisions, governance of natural resources, defining which policy objectives should be pursued. Finally, the interactions in the social networks determine how people value, use and demand different ESs (Dee et al., 2017), which will be related to various indicators related with DOs.

In this work, the socio-ecological network approach was adopted with the main scope of detecting key barriers to the ES production and provision, due to the misfit between the social and the ecological network. The activities detailed in the following are mainly based on a specific semi-structured individual interview performed with key stakeholders in pilot areas before the 1st stakeholder workshop, whose results were integrated with the evidence from the baseline description (D8.1) and then revised according to the progress in the WP5 and WP6 activities on ESs assessment. The following Table 1 describes the different steps of the adopted methodology.

Table 1 Overview of the steps of the methodological approach used.

Step	Objective	Adopted method
ES definition	To identify the key ES that ought to be produced in order to guarantee a satisfactory level of security in the Nexus domains	Individual semi-structured interviews with key stakeholders in the different Nexus domains were conducted. ES needs were detected in the stakeholders' narratives.
Ecological network	To build the network of ecological resources and processes affecting the ES production and provision.	A combination of stakeholders' knowledge elicitation and analysis and literature review was adopted in this step to identify the ecological resources and define the different connections.
Social network	To build the network connecting the different stakeholders and decision-makers involved in ES production, provision and use.	The results of the individual interviews were used to map the different interactions among the stakeholders and decision-makers. Different kinds of interactions were mapped: i.e. information sharing, regulating, controlling, resources sharing.
Barriers detection	To detect and analyze barriers to ES production and provision due to misalignment between social and ecological networks.	The socio-ecological network analysis was used to identify and analyze potential misfits between the social and ecological network hampering the ES production and provision.

3.1. PSDM Exercises

For the purposes of the present deliverable the results in two pilot areas (i.e. Doñana and Tarquinia plain) are described as example. PSDM exercises have been performed in all LENSES pilots, although with a different focus and different level of detail (please refer to the D4.2 for further details). Socio-ecological network in the Doñana pilot.

A round of semi-structured interviews was conducted in the Doñana pilot involving the following stakeholders (Table 2):

Table 2 List of stakeholders involved in the Doñana pilot.

Stakeholder	Main sector(s)	Main Role(s)	Interview format
Spanish Geological Survey (IGME)	Water	Research	Online
Guadalquivir river basin authority (CHG)	Water	Water resources management	Online
Farmers Union – ASAJA	Food production	Providing technical support to farmers	In person
Doñana Nature	Ecosystem	SME organizing touristic trips in the Doñana protected area	In person
Farmers	Food production	Rice cultivation	In person
WWF	Ecosystem	Environmentalist NGO, with a specific working program in Doñana	In person
Optiriego	Food production	SME Providing technical support to farmers in irrigation optimisation	In person
Water policy expert	Water	Expert in groundwater management and protection	In person
Regional Authority – Agriculture Dept.	Food production	Land use policy and agriculture management	In person

The results of the interviews were used to both start building the Causal Loop Diagram (described in the D4.2), and to map the connections among actors, processes and ecological resources influencing the production and use of the ESs for the Nexus security.

Following the methodology described in the previous section, the results of the interviews were analyzed to detect the key ESs to be produced according to the stakeholders' perceptions. The following Table 3 shows the results of this analysis.

Table 3 List of ES considered in the Doñana pilot.

ES type	ES description	Resources involved	Nexus security	Main beneficiaries
Regulating	Water flow regulation (flood control)	Wetland marshland	Ecosystem security, food security	The River Basin Authority of the Guadalquivir (CHG), local communities
	Water flow regulation (drought control)	Rivers Groundwater	Ecosystem security, food security	CHG, local communities
	Regulation of the chemical conditions of freshwaters (SW quality and GW quality) Water purification	Soil	Ecosystem security, water security	Ecosystem, farmers
Provisioning	(Surface, subsurface ground) water for ecosystem (non-drinking purposes)	Groundwater Rivers Wetlands Marshland	Water security, ecosystem security	Ecosystem, tourism sector, local communities
	Surface water for agriculture (non-drinking purposes) Groundwater for agriculture (non-drinking purposes)	Groundwater River Guadalquivir	Water security, food security	Farmers, local communities
	Maintaining the quality of ecosystem (Maintaining nursery population and habitats)	Groundwater Rivers Wetlands Marshland	Water security, ecosystem security	Ecosystem, tourism sector, local communities
Cultural	Recreation and ecotourism (Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions)	Wetlands; Marshland	Ecosystem security	Local community Tourists

Most of the stakeholders perceived the provisioning ESs as key for the Nexus management. Specifically, water provisioning for the ecosystem and water provisioning for agriculture are the two most important ESs, as perceived by the stakeholders. However, the lack of inter-sectoral policies is provoking a strong conflict between these two ESs and their beneficiaries.

The main goal of this analysis was to detect barriers to the ESs production due to the misfit between the social and the ecological network of interactions. The first conflict that emerged during the interviews was the one involving the Regional Authority and the CHG. As described further in the text (see the section on the SDM), the Regional Authority is enforcing a new plan for land-use and the management of water resources. According to this plan, most of the areas currently irrigated - even if illegally - are officially considered 'irrigable' (i.e. which in practical terms means that can be legalized in the near future). However, the permits to use the groundwater for irrigation purposes should be issued by the CHG. In this situation, there are two institutional actors, managing different ecological resources - i.e. the Regional Authority is responsible for the land-use plan, whereas the CHG is responsible for the management of the water resources - producing two ESs, whose effectiveness in achieving the food security is hampered by the lack of coordination. The following **Errore. L'origine riferimento non è stata trovata.** shows this condition.

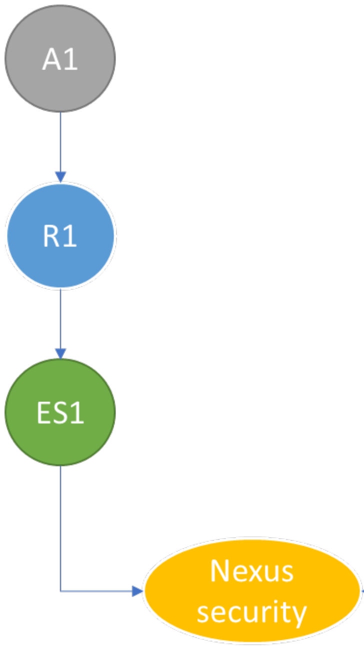

Figure 1 Graphical description of the process of ES production (affected by different agents A and involving the resources R) affects Nexus security.

The two agents need to work cooperatively in order to achieve a satisfactory level of Nexus security. The conflict is mainly due to the different perceptions about the ESs that need to be produced. While the Regional Authority perceives food security as a key dimension of the Nexus, since it strongly affects the local community's well-being, the CHG attributes the highest priority to the protection of the quality and quantity of the water resources and, consequently, of the ecosystem. This is a clear example of a vertical misfit between the ecological and social networks (Bodìn, 2017). This condition would require the presence of a mediating agent operating at a higher administrative level, capable of activating cooperation between the two benefitting agents to find a consensual solution. In this regard, it is worth remembering that coordination in collective decision-making corresponds to the situation where agents display different opinions and interests. Currently, the coordination agent does not exist hampering the reaching of a common agreement. This conflicting situation is hampering the production of the ESs for the Nexus security and resilience.

Another key conflict involves the CHG and the farmers and concerns the management and use of the groundwater. In this case, the two agents share the same ecological resource - i.e. the groundwater - but have completely different perceptions about the ESs that should be produced. Farmers perceive groundwater as a source of water (water provisioning) for irrigation purposes. CHG considers groundwater as a vulnerable resource to be protected in order to preserve the ecosystem equilibrium. Addressing this ambiguity in the role of groundwater would require effective interaction mechanisms between these two actors. As demonstrated by (Giordano et al., 2021), ambiguity in problem understanding does not hamper the achievement of consensus over the actions to be implemented and the goals to be achieved, if effective and consolidated interactions connect the two agents. In the Doñana case, the only connection between CHG and farmers is the one related to the water permits regulation and territory control. The lack of interactions aiming at facilitating knowledge exchange and awareness-raising - e.g. technical support from the CHG toward farmers - is affecting the cooperation between these two agents.

Another key barrier is due to the role of the National Park Management Authority. This actor seems to be completely isolated in the network of interactions. It does not interact either with the CHG nor with the farmers. It seems to neglect the impacts of the water management and uses on the quality of the ecosystem and ecological resources in the national park. This lack of cooperation is hampering the possibility to raise farmers' awareness concerning the impacts of their activities on the ecological resources.

Finally, a key barrier to Nexus's sustainable management is related to the lack of social capital within the farmers' community. Farmers tend to assume a rather individualistic and competitive behavior. They prefer to interact directly with the market agents - i.e. the big distribution - instead of creating farmers' cooperation. This has a twofold negative impact on the Nexus. On the one hand, the lack of farmers' social capital reduces their capability to negotiate with the market agents. The farmers tend to use their resources - including the groundwater - to increase their production and succeed in the competition with the other farmers. On the other hand, the lack of cooperation within the farmers' community represents a barrier to the creation of the Water Users Associations (WUAs). As described further in the text, the WUAs play a key role in facilitating the control of the territory and the protection of the water resources in case of declaration of an overexploited aquifer.

The following Table 4 shows the main findings of this phase of analysis according to the results of the stakeholders' interviews.

Table 4 List of the main barriers to ES production in the Doñana pilot

Detected barrier	**Involved actors**	**Impact on ESs**
Lack of coordination	Regional Authority and CHG	The lack of a coordinating actor affects the conflicts for the implementation of the land-use management plan and the groundwater protection policy.
Lack of awareness-raising campaign and technical support	CHG and farmers	Farmers perceive the CHG simply as a controlling entity. This negatively affects the effectiveness of a negotiation process.
Lack of farmers' social capital	Community of farmers, market agents	The lack of cooperation within the community of farmers is increasing the competition for food production, which is detrimental to the GW protection.
Limited role of the National Park management authority	National Park management authority, farmers	The limited interaction between this agent and the farmers is reducing the effectiveness of the awareness raising campaigns.
Lack of WUA formation	Farmers, WUA, CHG	The lack of farmers' social capital affects the process for the formation of WUAs, which are supposed to play a key role in supporting CHG in the control of the territory.

The interaction with stakeholders helped better understanding the perceptions of the complex, and non-linear, connections among the different elements affecting the Nexus sustainable management and resilience. The collected knowledge was, then, structured in Causal Loop Diagrams (CLDs), which allow to analyze the connections among ecological resources, ecological and human processes and the production and provision of ecosystem services (ESs). The ESs play a key role in the analysis since they contribute to transforming the potentiality of a health ecosystem into services for the achievement of the main sectoral Nexus securities - i.e. water, ecosystem and food security.

To this aim, a common framework for the interviews was used in the LENSES pilots. The questions aimed at collecting and structuring stakeholders' perceptions about the main ESs to be produced in to achieve a satisfactory level of the Nexus domain securities, the key ecological resources and processes to be activated, the main pressures on the ecological resources and barriers – e.g. institutional, infrastructural and perceptional - affecting the actual production and use of the ESs for the Nexus management and resilience. The framework for the interviews was structured in such a way to collect stakeholders' understanding of the non-linear cause-effects chains connecting the above-mentioned elements. The results from the interviews, along with baseline information on the pilot area (see D8.1), were used to build a CLD (detailed in D4.2) to describe the cause-effects web of non-linear connections affecting the production of ESs, according to the stakeholders' problem understanding.

3.2. 2Socio-ecological network in the Tarquinia pilot

A round of semi-structured interviews was conducted in the Tarquinia pilot involving the following stakeholders (Table 5):

Table 5 List of stakeholders involved in the Tarquinia pilot.

Stakeholder	Main sector(s)	Main Role(s)	Interview format
ENZA ZADEN	F	Innovation in crops and vegetables, seeds	Online
Tarquinia Municipality	W-E	Drinking water management, wastewater treatment, territorial planning, policy-making	In person
Università Agraria	F-E	Management and use of public land (agricultural, forest, pasture)	In person
ISLA S.r.l.	F	Research and development in bio-fertilizers and phytonutrients	In person
COT (Farmer Cooperative)	F	Coordination of agricultural trade, support to farmers	In person
Cooperativa Pantano (Farmer Cooperative)	F	Coordination of agricultural trade, support to farmers	In person
3 farmers (different farm size)	W-F	Food production, irrigation activities	In person
1 biological farm	W-F	Food production, irrigation activities	In person
Biodistretto Maremma Etrusca e Monti Tolfa	F-E	Support of agroecology and sustainable development model	Online
CBLN (Consorzio d Bonifica Litorale Nord)	W	Water provision for irrigation, river management	Online
LIPU Birdlife	E	Protection of ecosystems	Online

The results of the interviews were used to both start building the Causal Loop Diagram (described in the D4.2), and to map the connections among actors, processes and ecological resources influencing the production and use of the ESs for the Nexus security.
Following the methodology described in the previous section, the results of the interviews were analyzed to detect the key ESs to be produced according to the stakeholders' perceptions. The following Table 6 shows the results of this analysis.

Table 6 List of ES considered in the Tarquinia pilot.

Ecosystem Service type	ES description	Resources involved	Nexus security	Main beneficiaries
Regulating	Water flow regulation (flood control)	River, Banks and riparian areas	Water security, Food security	Local communities, farmers
	Erosion regulation (Regulation of physical, chemical, biological conditions)	Soil	Ecosystem security	Local communities, farmers, ecosystem
	Maintaining nursery population and habitats	River, forested and natural areas, natural reserves, saltworks	Ecosystem security	Ecosystem, tourists, environmentalists
	Regulation of the chemical conditions of freshwaters (SW quality and GW quality)	Groundwater River (Marta)	Water security	Local communities, farmers, ecosystem
	Soil quality and fertility (weathering processes, decomposition and fixing processes)	Soil	Food security, ecosystem security	farmers, ecosystem
Provisioning	(Surface, subsurface ground) water for ecosystem (non-drinking purposes)	Groundwater River (Marta) Saltworks	Water security, ecosystem security	Ecosystem
	Surface water for agriculture (non-drinking purposes) Groundwater for agriculture (non-drinking purposes)	Groundwater River (Marta)	Water security, food security	Farmers, cooperatives, CBLN
	Cultivated terrestrial plants for nutritional purposes	Soil	Food security	Farmers and cooperatives, large retailers
	Solar energy	Energy from sunlight, Soil	Energy security	Farmers, productive activities
Cultural	Recreation and ecotourism (Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions)	Natural reserves, coastal area, Saltworks	Ecosystem security	Tourists, local communities, environmentalists

Referring to the above list of ESs, a key role is played by the regulation of the conditions of both surface water (SW) and groundwater (GW), as the quality of water has significantly deteriorated over the area. The quantity, instead, is not currently an issue but there is an increasing threat due to the potential effect of climate change coupled with the growing request for irrigation water (even during winter) which is not currently distributed and managed with high efficiency. Water provisioning for the ecosystem is also crucial, and currently impacted by the provision to agriculture and by the quality issues that are related to unsustainable agricultural practices. Soil quality is also currently a key challenge, as soil fertility directly affects the agricultural productivity and cultivated plants, and increasing erosion rates characterize some areas of the basin.

As highlighted before, detecting barriers to the ESs production due to the misfit between the social and the ecological network of interactions, is central at this stage. Interestingly, there are no 'explicit' conflicts in the water sector mainly due to the availability of water which, in current conditions, is typically available for irrigated agriculture. However, as further described later in the section on the PSDM, there are increasing concerns related to the resource management, as the demand is increasing (following an increase in intensively cultivated areas) and there are growing quality issues, which can be partly attributed to agricultural practices. More in general, there is a perceived lack in land-use planning effectiveness as e.g. some areas are being devoted to intensive almond/hazelnut trees growth and other highly productive areas are being instead used for installing solar panels. Furthermore, at a lower scale, the need for farmers to sustain their business following the market requirements does not allow a rational and sustainable planning of crops and agricultural land use. A weakness in the social network concerns the role of the farmers' cooperative groups. Contrarily to the Doñana case, the area is characterized by the existence of several cooperatives composed of farmers. Their role should be to mediate between the producers (farmers) and the buyers (the great distribution), in order to enhance the farmers' revenue. However, their negotiation power is perceived as rather low by farmers. The social capital within the farmers' community is decreasing, leading them to assume a rather competitive behavior. The competitive behavior and the low price of the agricultural products in the market push farmers to increase the quantity of the production, with an ever-increasing pressure on the ecological resources due to the excessive use of fertilizers.

A further weakness is related to the limited interaction between the irrigation consortium and the environmentalist associations. The consortium perceives the rivers simply as a source of water for irrigation. It does not account for the impacts of water exploitation on the quality of the river water and of the ecosystem at the river outlet. The low level of water in the river, specifically during the summer period, and the high level of wastewater discharge negatively affects the quality of the coastal area as well.

In this situation, therefore, there is very limited control on the impacts of agricultural activities on the state of SW (Marta river), GW and soil. Moreover, there is a lack of coordination among public authorities involved in river management, particularly as far as risk management and reduction is concerned. The CBLN is in charge of ordinary maintenance of the rivers (Marta and Mignone in the area), although the increasing frequency of extreme events (e.g. floods) would require a more coordinated and effective action over the whole system.

The soil is probably the key ecological resource for the area, as the land is traditionally fertile and productive for agriculture, and there are some high-value natural areas. However, it is increasingly threatened by a multiplicity of stressors, mainly related to unsustainable agricultural practices (abundant use of traditional fertilizers, overexploitation of land, and expansion of agricultural activities in natural areas). In this direction a barrier has been highlighted by several farmers and cooperatives, which is the lack of awareness coupled with the limited technical support. Many farmers have a strong resistance to change (as are still oriented to pursue the short-term maximization of land productivity), but this aspect is also magnified by the very limited availability of technical information on the benefits of innovative techniques (e.g. bio-fertilizers), which still look costly considering the marginal profit currently associated to food production. Some initiatives for an improved coordination (e.g. the development of specific certifications and the development of the Biodistretto), for knowledge sharing and for supporting market niches are being increasingly promoted.

The expansion and the intensity of agricultural practices and the related impacts is also deeply impacting the environment. The area is a touristic place, thanks to the value of natural landscapes and to the archaeological sites, but the ecosystem security is increasingly endangered by such practices.

Table 7 List of the main barriers to ES production in the Tarquinia pilot

Detected barrier	**Involved actors**	**Impact on ESs**
Lack of planning and territory control	Public authorities (Region, Municipalities, etc.)	The lack of coordination originates from a poor land-use management plan (with an uncontrolled development of agricultural which is central for the area), and limited control of the state of natural resources (SW, GW and soil). This also reflects in a poor maintenance and control of the river.
Lack of awareness-raising campaign and technical support	Public authorities and farmers	Farmers do not perceive yet a support in the innovation processes at farm level (including the access to funding and to specific initiatives).
Lack of farmers' social capital	Community of farmers, market agents	The lack of cooperation within the community of farmers is increasing the competition for food production, which is detrimental to the SW, GW and soil protection.

3.3. PSDM development

The understanding of the socio-ecological network in the LENSES pilot areas was central for the development of PSDM in Task 4.2. In particular, the preliminary development of Causal Loop Diagrams was significantly helped by the integration of background knowledge related to pilot areas (D8.1) with the evidence from the semi-structured interviews with the stakeholders. The preliminary round of interviews was oriented to build and understand the 'sectoral' perspective to resources security and to highlight needs and potential conflicts in the use of natural resources and in the production of ESs and was crucial to understand sectoral (and potential cross-sectoral) implications of resources management and use. The sectoral perspective has been gradually turned into a 'Nexus' approach particularly through the stakeholder workshops, that have been used to facilitate dialogue and build a clear overview of the interconnections among resources. The whole process resulted in a dynamic update of the CLDs throughout project duration as detailed in the D4.2. In selected pilots the CLD are also being translated into stock and flow models, and particular attention is being given (as much as possible) to the modelling of variables - and related dynamics - that can describe the relevant DOs, NIs and NRQs.

This project is part of the PRIMA programme supported by the European Union.
GA n° [2041] [LENSES] [Call 2020 Section 1 Nexus IA]

4. 3Nexus Domain Objectives (DOs) of the Pilots

One of the main objectives of LENSES is to build resilient Nexus systems, which can adapt to changes and disruptions. Adaptation requires the assessment of the current situation of the Nexus domains as well as the identification of the WEF Nexus challenges. These aspects have been analyzed though bilateral meetings with the pilot leaders and informed by the results derived from the semi-structured interviews with key stakeholders. In particular, a key element of the interview performed with stakeholders was the identification of 'variables' that can be used to measure the level of achievement of the needs related to resources security. This helped screening the potential 'indicators' to characterize domains in separation, and the whole Nexus. In some cases, the discussion on indicators was then part of the stakeholder workshops and stakeholders were also asked to discuss together indicators and related issues such as data availability.

In part "WEF Challenges" have multiple similarities among the pilots, which is natural given they are all located scattered across the Mediterranean region. Among the pilots' WEF Challenges, water scarcity and degraded water and soil quality are very common. Along with WEF Challenges, pilots were asked to describe their aspirations of future and their objectives. These objectives of the pilots have been categorized by the Nexus Domains, under the form of Domain Objectives (DOs) (Table 8).

The identification of DOs, as well as of NIs and NRQs has been preliminarily performed in all of the LENSES pilot areas, although results could be revised/updated as new knowledge emerges throughout project activities. The identified indicators have been also integrated with PSDM at later stages (in particular, with the development of stock and flow models, see D4.2), as the models developed have provided information on a sub-set of key indicators for the pilot areas. As it can be observed through Tables 10, 11 and 12, in comparison to preliminary analysis, some of the pilots added more Nexus challenges and objectives which are revealed through the participatory processes of LENSES project mentioned above.

Table 8 Nexus domain objectives of pilots

<table>
<tr><th rowspan="2">Pilot</th><th rowspan="2">WEF Challenges</th><th colspan="3">Nexus Domain Objectives</th></tr>
<tr><th>Water</th><th>Ecosystem</th><th>Food</th></tr>
<tr><td>Doñana</td><td>☐ Ground and surface water resources have been reduced significantly due to droughts and over-irrigation (climate change- hydrologic extremes).
☐ The marshlands of Doñana and food security in the pilot are under threat.</td><td>1) Increase the irrigation water efficiency
2) Water allocation challenges/competition among sectors</td><td>1) Increase the annual flow to marshlands
2) Increase the implementation of NBSs
3) Restore/increase biodiversity</td><td>1) Crop pattern change to increase drought resilience</td></tr>
<tr><td>Tarquinia</td><td>☐ Due to intensive agriculture, quantity and quality of irrigation water has been deteriorated.
☐ Soil degradation, lack of technology in agricultural management and economic pressures are significant.</td><td>1) Increase the irrigation water efficiency
2) Increase availability and sustainable management of irrigation water</td><td>1) Increase the implementations of NBSs
2) Restore/increase biodiversity</td><td>1) Increase the agricultural infrastructure(tech)
2) Increase cost efficiency</td></tr>
<tr><td>Koiliaris</td><td>☐ Poor water management, under climate change
☐ Soil degradation, water erosion due to intensive agriculture and inappropriate cultivation practices
☐ De-vegetation due to livestock grazing</td><td>1) Increase the irrigation water efficiency by irrigating the tree and not the field
2) Increase local stakeholder participation with governmental authorities to water management</td><td>1) Increase the implementations of NBSs
2) Restore/increase biodiversity
3) Reduce the environmental pressures to ecosystems</td><td>1) Agroecological and NBS practices to increase food production
2) Improve agricultural infrastructure (tech)</td></tr>
<tr><td>Pinios</td><td>☐ Lack of water saving awareness.
☐ Limited efficiency of irrigation methods.
☐ Wide application of pesticides affecting soil organic matter content.
☐ Medium to high sensitivity of crops to droughts.</td><td>1) Increase the irrigation water use efficiency.
2) Increase awareness of farmers on capillary rise contribution to crop water needs fulfilment.</td><td>1) Increase the implementations of NBSs.
2) Maintain or improve the conservation status of ecosystems.</td><td>1) Crop pattern change to increase extreme events resilience.
2) Secure farmers' income against fluctuations of agricultural inputs costs.</td></tr>
</table>

This project is part of the PRIMA programme supported by the European Union.
GA n° [2041] [LENSES] [Call 2020 Section 1 Nexus IA]

Table 9 Nexus domain objectives of pilots (Continued)

Pilot	WEF Challenges	Nexus Domain Objectives		
		Water	**Ecosystem**	**Food**
Menemen	☐ Irrigation water scarcity due to urbanization and industrialization ☐ Groundwater depletion and soil salinity ☐ Economic viability	1) Increase the irrigation water efficiency 2) Reduction of leakages 3) Desalination	1) Increase the implementations of NBSs 2) Restore/increase biodiversity	1) Increase cost efficiency
Hula Valley	☐ Unsustainable water management in agriculture ☐ Water scarcity and cost ☐ Lack of technology in agriculture ☐ Application scale is on farm level	1) Increase the irrigation water efficiency	1) Increase the implementations of NBSs 2) Restore/increase biodiversity	1) Increase cost efficiency 29
Deir Alla	☐ Water quality/quantity management ☐ Soil degradation: salinization, erosion ☐ Lack of technology and marketing in agriculture	1) Increase the irrigation water efficiency 2) Increase the availability and sustainable management of irrigation water 3) Desalination	1) Increase the implementations of NBSs 2) Restore/increase biodiversity 3) Improvement soil fertility through using organic fertilizers	1) Increase cost efficiency 2) Reduce food waste (manage good post-harvest practices). 3) Improvement of land productivity.

Table 10 Final nexus domain objectives of the pilots.

Pilot	WEF Challenges	Nexus Domain Objectives		
		Water	**Ecosystem**	**Food**
Doñana	☐ Ground and surface water resources have been reduced significantly due to droughts and over-irrigation (climate change- hydrologic extremes). ☐ The marshlands of Doñana and food security in the pilot are under threat.	1) Water allocation challenges/competition among sectors 2) Increase the irrigation water efficiency 3) Restore water quality 4) Limit uncontrolled water withdrawals	1) Increase the annual flow to marshlands 2) Increase the implementation of NBSs 3) Restore/increase biodiversity	1) Crop pattern change to increase drought resilience 2) Increase farmers' awareness and improve practices
Tarquinia	☐ Due to intensive agriculture, quality of irrigation water has been deteriorated. ☐ Soil degradation, lack of technology in agricultural management and economic pressures are significant.	1) Increase the irrigation water efficiency 2) Protect water quality	1) Improve the land use planning 2) Restore/increase biodiversity 3) Increase the implementations of NBSs	1) Increase the agricultural infrastructure(tech) 2) Increase cost efficiency (and productivity)
Koiliaris	☐ Poor water management, under climate change ☐ Soil degradation, water erosion due to intensive agriculture and inappropriate cultivation practices ☐ De-vegetation due to livestock grazing	1) Increase the irrigation water efficiency by irrigating the tree and not the field 2) Increase local stakeholder participation with governmental authorities to water management	1) Increase the implementations of NBSs 2) Restore/increase biodiversity 3) Reduce the environmental pressures to ecosystems	1) Agroecological and NBS practices to increase food production 2) Improve agricultural infrastructure (tech)

This project is part of the PRIMA programme supported by the European Union.
GA n° [2041] [LENSES] [Call 2020 Section 1 Nexus IA]

Table 11 Final nexus domain objectives of the pilots (Continued).

Pilot	WEF Challenges	Nexus Domain Objectives		
		Water	Ecosystem	Food
Pinios	**Challenge for WATER**: Achieving and maintaining sufficient quantity and good quality of water resources. Problems: ☐ Spatial and temporal variation of the groundwater level in the Agia watershed ☐ Locally high nitrate concentrations in groundwater ☐ Lack of infrastructure projects (irrigation networks, reservoirs) **Challenge for ECOSYSTEM:** Protection and restoration of ecosystems Problems: ☐ Preservation of the ecological flow of the Pinios River ☐ High pressures on the riparian habitats of the Pinios River ☐ Irrational management of used agricultural packaging **Challenge for FOOD:** Sustainability of the agricultural sector. Problems: ☐ Increased production cost ☐ Irrational use of pesticides and other agricultural supplies ☐ Limiting available markets for agricultural exports	1) Improve water management and irrigation water use efficiency 2) Improve groundwater quality issues posed mainly by locally high nitrate concentrations	1) Increase the implementations of NBSs. 2) Rational use of agricultural supplies and corresponding packaging 3) Restoration and conservation of the riparian habitats of the Pinios River including the maintenance of Pinios River environmental flow	1) Crop pattern change and agricultural practices to increase extreme events resilience and maintain high agricultural productivity. 2) Secure farmers' income against fluctuations of agricultural inputs costs and markets availability.

Table 12 Final nexus domain objectives of the pilots (Continued).

Pilot	WEF Challenges	Nexus Domain Objectives		
		Water	Ecosystem	Food
Menemen	☐ Irrigation water scarcity, agricultural land decrease/degradation due to urbanization and industrialization ☐ Groundwater depletion and soil alkalinity ☐ Economic viability ☐ Use of inefficient irrigation methods, degradation of water quality	1) Increase the irrigation water efficiency 2) Reduction of leakages 3) Desalination 4) Recommending crop pattern according to water availability	1) Increase the implementations of NBSs 2) Restore/increase biodiversity	1) Increase cost efficiency
Hula Valley	☐ Unsustainable water management in agriculture ☐ Water scarcity and cost ☐ Lack of technology in agriculture ☐ Application scale is on farm level	1) Increase the irrigation water efficiency	1) Increase the implementations of NBSs 2) Restore/increase biodiversity 3) Reduce soil deterioration	1) Increase cost efficiency 2) Increase agricultural productivity and socio-economic well-being
Deir Alla	☐ Water quality/quantity management ☐ Soil degradation: salinization, erosion ☐ Lack of technology and marketing in agriculture	1) Increase the irrigation water efficiency 2) Increase the availability and sustainable management of irrigation water 3) Desalination	1) Increase the implementations of NBSs 2) Restore/increase biodiversity 3) Improvement soil fertility through using organic fertilizers	1) Increase cost efficiency 2) Reduce food waste (manage good post-harvest practices). 3) Improvement of land productivity.

5. List of Nexus Indicators (NIs)

The progress and the succession of the Nexus DOs have been measured through the Nexus Indicators (NIs). NIs summarized the state of DOs both separately and combined as the project progressed. Although the project defines the Nexus Domains as Water, Ecosystem and Food, other domains inherently related and inseparable from these domains have also been taken into consideration. Energy, Socio-Economy, Climate Change and Gender Equality domains have been added to the Nexus for evaluation by the pilots. An inventory of NIs was created in previous version of this document and listed in Annex I. Those indicators are selected from the collective indicator archives of European Environment Agency (EEA, 2022), United Nations Educational, Scientific and Cultural Organisation (UNESCO, 2022) and World Bank (WB, 2022). Selected NIs are classified and coded according to their associated domain, moreover their definitions, rationale, methodology, unit and spatial and temporal extent have also provided for the pilots.

6. Identifying Nexus Resilience Qualities (NRQs)

NRQs are defined in terms of socio-economic and legislative infrastructures, implementation directives of public, governmental and non-governmental organizations (NGOs), regulations, etc. that are already existing in and supporting the resilience of the WEF Nexus environments. Currently available NRQs should be retained for further improvement of Nexus environments. Main topics related to NRQs are Economic Resources, Social Capital, Awareness & Training, Technology, Infrastructure and existing institutional structure to support the adaptive capacity (Chandra and Uniyal, 2021). A selection of NRQs was provided in Annex 3 of D4.1 in first reporting period, which the pilot cases have surveyed for the existence of these qualities for their case studies. The following table of NRQs available on the pilots has been formed according to the pilots' feedback.

Table 13 Available Nexus Resilience Qualities for each pilot.

Pilot	Available Nexus Resilience Qualities
Doñana	1) **Access to family labour:** Understanding the resilience of labour forces working with minimal or no pay is critical for assessing the vulnerability of vulnerable workers in the region. This knowledge can inform targeted support programs, labour policies, and social safety nets to protect the economic well-being of these workers during times of crisis or change. 2) **Participation in agri-based organisation:** Assessing the extent of organization within agricultural communities is essential to gauge their ability to collectively respond to challenges and sustainably manage resources. Communities with higher organization extensity are more likely to adapt to changing conditions, share best practices, and make informed decisions, leading to improved resilience in the WEF Nexus context. 3) **Knowledge & acceptance of climate change:** Promoting climate literacy and future climate impact awareness is crucial for building resilience in the face of climate change. By enhancing the community's understanding of climate change effects, it becomes easier to develop and implement adaptive strategies, mitigate risks, and safeguard the environment and livelihoods. E.g. reduce consumption of water resources. 4) **Soil moisture and fertility:** the relationship between soil moisture and ecosystem resilience, including its impact on irrigation dependence and food production. It's highly relevant as it addresses both environmental and economic aspects of the WEF Nexus.

Pilot	Available Nexus Resilience Qualities
Tarquinia	1) **Innovation:** promoting innovation in agriculture is important for a better management of resources particularly water, for cost reduction and consequently a higher profitability 2) **Access to credits:** Creating a good access network for farmers supports the innovation and the technological improvement of the farm 3) **Knowledge & acceptance of climate change:** The awareness of the consequences of climatic changes on the territory, could help stakeholders to decide what agronomic management changes to make in the future. 4) **Access to subsidy:** Access to subsidies can help farmers in periods of low income due to extreme events caused by climate change and can increase unduly low profits for investments in farms 5) **Local networks:** improving the knowledge-sharing and knowledge co-production of stakeholders is crucial for building innovation for climate change reliance. 6) **Reciprocity:** Improving reciprocity is a very important element that leads farmers' cooperatives to higher performance levels and to implement innovation tools in their farms.
Koiliaris	1) **Participation in an agri-based organisation:** Number of farmers from the Biological Avocado Association participating in the LAA activities 2) **Soil moisture and fertility:** the relationship between soil moisture and ecosystem resilience, including its impact on irrigation dependence and food production. It's highly relevant as it addresses both environmental and economic aspects of the WEF Nexus. 3) **Irrigation facilities:** Technologies used to optimize irrigation demand 4) **Water Governance:** Number of institutions and interdependence related to water governance and associated nexus issues
Pinios	1) **Innovation in irrigation practice:** the development of large-scale irrigation networks, the wider development of agricultural cooperatives, and the adoption of smart technologies can help optimizing the use of water resources in agriculture. Economic support is needed to implement this strategy. 2) **Soil Moisture:** Traditional practices to maintain soil moisture are implemented in farming practices. 3) **(Water) Governance:** Number of institutions and interdependence related to water governance and associated nexus issues, along with a higher attention to the environmental implications of water use. 4) **Soil fertility:** The area is characterized by high productivity and has a huge potential for agricultural activities. Farmers also show a significant experience. 5) **Knowledge and skills:** Institutions and scientific bodies have huge experience, as well as farmers. There is a good awareness of 'Nexus' and an increasing awareness of climate change impacts (including the role of extremes).
Menemen	1) **Infrastructure (Irrigation facilities):** Current irrigation system and level of accessibility to water from sources. Technologies used to optimize irrigation demand. 2) **Technology (Eco-friendly techniques):** Technologies used to get benefit in terms of Nature Based Solutions 3) **Awareness & Training (Formal & informal training):** Increasing the adaptation potential by holding both technical and demonstrative applications by training activities regarding nexus understanding & doing. 4) **Institution (Water Governance):** Number of institutions and interdependence related to water governance and associated nexus issues. State Hydrology Works and Menemen Water Users Association is in charge. 5) **Institution (Governance systems):** Number of institutions and interdependence related to nexus issues. Provincial and district directorates of Ministry of Agriculture and Forestry. Research Institutions affiliated to the Ministry.

Pilot	Available Nexus Resilience Qualities
Hula Valley	1) **Institution (Water Governance)** 2) **Economic Resources (Diversity of source of income)** 3) **Awareness & Training (Access to agri-based information)** 4) **Technology (Soil moisture)** 5) **Technology (Innovation):** The innovation in agriculture may help increasing production and reducing soil deterioration, providing multidimensional benefits. The development of solar-integrated agricultural projects can have a crucial role in this direction. 6) **Infrastructure/irrigation facilities**: The implementation of the Hula Restoration project, which includes new drainage canals, a small lake and large-scale surface irrigation equipment can support the agricultural activities over the area while providing also relevant co-benefits (e.g. recreation and eco-tourism).
Deir Alla	1) **Economic Resources:** The main economic resources are land, water, forage, and technology. Technology is sometimes referred to as the development of new applications for silage. Land, energy, and water are considered the main natural resources that will be used properly for the optimization of forage production. 2) **Technology:** Technology will be used to optimize the quality of produced forage by being utilized for silage purposes. We will develop our own feed formulation software model by using scientific knowledge to manage and reduce the feeding cost using random feed rations. 3) **Awareness & Training:** Capacity-building training courses will be conducted intensively for the extension agents of the Ministry of Agriculture specialized in livestock production in order to increase their skill and awareness of the importance of alternative feed resources and the best practices in forage production and evaluation. 4) **Social Capital:** we will share the value knowledge and local resources with extension agents linked with small ruminant farmers to work together as a group to effectively achieve a common purpose of best farming management mainly focusing on animal feeding and forage production. 5) **Infrastructure:** We have the basic infrastructure for our demonstration field for research purposes and we are looking to expand our facilities and infrastructure in order to serve the larger area of forage planting as well as large-scale silage production to provide service and consultation for small ruminant sector and convince large farmer and investor to adopt the technique.

7. Recommendations for NIs according to pilot feedbacks

According to the surveyed data availabilities of the pilots in previous D4.1 and their DOs (Table 8 in previous D4.1) a cross match has been made to propose to each pilot a list of suitable NIs. Since the DOs are pilot specific, a set of NIs is recommended for each pilot separately (Table 14-15-16).

Regarding the progress of the project, pilot areas have selected and adopted their desirable indicators. Those indicators are selected via available resources, stakeholder involvement (questionnaires and meetings) and also PSDM exercises conducted. Although some of the indicators are immeasurable, not eligible due to available data restrictions, the majority of the indicators are monitored and quantified during the progress of the LENSES project. The Tables 17 to 24 summarize for the pilot areas separately, the indicators selected, the domain objective of the selected indicator related with NEXUS and overall values measured, monitored, qualified or quantified. However, as the consequence of the unfortunate events happened in the Middle East Region, no input has been received yet for Hulla Valley pilot area.

Table 14 Recommended list of NIs (Doñana and Tarquinia)

Nexus Domain	Doñana		Tarquinia	
	Objective	Related NIs	Objective	Related NIs
Water	1) Increase the irrigation water efficiency	LNS-W07, LNS-W13, LNS-W33, LNS-F06	1) Increase the irrigation water efficiency	LNS-W07, LNS-W13, LNS-W33, LNS-F06
Water	2) Water allocation challenges/competition among sectors	LNS-W04a, b, c, d, LNS-W05a, b, c, d, LNS-W06a, b, c, d, LNS-W07, LNS-W10, LNS-W11a, b, c, d, LNS-W12a, b, c, LNS-W33, LNS-E01	2) Increase availability and sustainable management of irrigation water	LNS-W06a, b, c, d, LNS-W07, LNS-W11a, b, c, d, LNS-W12a,b,c, LNS-F06
Ecosystem	1) Increase the annual flow to marshlands	LNS-E14a, LNS-W34	1) Increase the implementations of NBSs	LNS-F07
Ecosystem	2) Increase the implementations of NBSs	LNS-F07	2) Restore/increase biodiversity	LNS-E10, LNS-E11, LNS-E12, LNS-E14a, b, LNS-E15, LNS-E29, LNS-E30, LNS-E31, LNS-E32, LNS-E33, LNS-E34
Ecosystem	3) Restore/increase biodiversity	LNS-E10, LNS-E11, LNS-E12, LNS-E14a, b, LNS-E15, LNS-E29, LNS-E30, LNS-E31, LNS-E32, LNS-E33, LNS-E34		
Food	1) Crop pattern change to increase drought resilience	LNS-W13, LNS-F01, LNS-F02, LNS-F03, LNS-F06, LNS-F07	1) Increase the agricultural infrastructure (tech)	LNS-S08
Food			2) Increase cost efficiency	LNS-E01, LNS-F05, LNS-01, LNS-S02, LNS-S03, LNS-S04

Table 15 Recommended list of NIs (Koiliaris and Pinios).

<table>
<tr><th rowspan="2">Nexus Domain</th><th colspan="2">Koiliaris</th><th colspan="2">Pinios</th></tr>
<tr><th>Objective</th><th>Related NIs</th><th>Objective</th><th>Related NIs</th></tr>
<tr><td rowspan="2">Water</td><td>1) Increase the irrigation water efficiency by irrigating the tree and not the field</td><td>LNS-W07, LNS-W13, LNS-W33, LNS-F06</td><td>1) Increase the irrigation water efficiency</td><td>LNS-W07, LNS-W13, LNS-W33, LNS-F06</td></tr>
<tr><td>2) Increase local stakeholder participation with governmental authorities to water management</td><td>LNS-G01, LNS-S06</td><td>2) Increase awareness of farmers on capillary rise contribution to crop water needs fulfilment.</td><td>LNS-S07</td></tr>
<tr><td rowspan="3">Ecosystem</td><td>1) Increase the implementations of NBSs</td><td>LNS-F07</td><td>1) Increase the implementations of NBSs</td><td>LNS-F07</td></tr>
<tr><td>2) Restore/increase biodiversity</td><td>LNS-E10, LNS-E11, LNS-E12, LNS-E14a, b, LNS-E15, LNS-E29, LNS-E30, LNS-E31, LNS-E32, LNS-E33, LNS-E34</td><td rowspan="2">2) Maintain or improve the conservation status of ecosystems.</td><td rowspan="2">LNS-E01, LNS-E10, LNS-E11, LNS-E12, LNS-E14a, b, LNS-E15, LNS-E16, LNS-E17, LNS-E19, LNS-E20, LNS-E21, LNS-E22, LNS-E30, LNS-E31, LNS-E32, LNS-E33, LNS-E34</td></tr>
<tr><td>3) Reduce the environmental pressures to ecosystems</td><td>LNS-E01, LNS-E10, LNS-E11, LNS-E12, LNS-E14a, b, LNS-E15, LNS-E16, LNS-E17, LNS-E19, LNS-E20, LNS-E21, LNS-E22, LNS-E30, LNS-E31, LNS-E32, LNS-E33, LNS-E34</td></tr>
<tr><td rowspan="2">Food</td><td>1) Agroecological and NBS practices to increase food production</td><td>LNS-W13, LNS-F01, LNS-F02, LNS-F03, LNS-F06, LNS-F07</td><td>1) Crop pattern change to increase drought resilience</td><td>LNS-W13, LNS-F01, LNS-F02, LNS-F03, LNS-F06, LNS-F07</td></tr>
<tr><td>3) Improve agricultural infrastructure (tech)</td><td>LNS-S08</td><td>2) Secure farmers' income against fluctuations of agricultural inputs costs.</td><td>LNS-F04, LNS-F08, LNS-F09, LNS-S01, LNS-S03, LNS-S04</td></tr>
</table>

PRIMA PARTNERSHIP FOR RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA

This project is part of the PRIMA programme supported by the European Union.
GA n° [2041] [LENSES] [Call 2020 Section 1 Nexus IA]

Table 16 Recommended list of NIs (Menemen, Hula Valley and Deir Alla).

Nexus Domain	Menemen		Hula Valley		Deir Alla	
	Objective	**Related NIs**	**Objective**	**Related NIs**	**Objective**	**Related NIs**
Water	1) Increase the irrigation water efficiency	LNS-W07, LNS-W13, LNS-W33, LNS-F06	1) Increase the irrigation water efficiency	LNS-W07, LNS-W13, LNS-W33, LNS-F06	1) Increase the irrigation water efficiency	LNS-W07, LNS-W13, LNS-W33, LNS-F06
	2) Reduction of leakages	LNS-W33			2) Increase the availability and sustainable management of irrigation water	LNS-W06a, b, c, d, LNS-W07, LNS-W11a, b, c, d, LNS-W12a,b,c, LNS-F06
	3) Desalination	LNS-E35			3) Desalination	LNS-E35
Ecosystem	1) Increase the implementations of NBSs	LNS-F07	1) Increase the implementations of NBSs	LNS-F07	1) Increase the implementations of NBSs	LNS-F07
	2) Restore/increase biodiversity	LNS-E10, LNS-E11, LNS-E12, LNS-E14a, b, LNS-E15, LNS-E29, LNS-E30, LNS-E31, LNS-E32, LNS-E33, LNS-E34	2) Restore/increase biodiversity	LNS-E10, LNS-E11, LNS-E12, LNS-E14a, b, LNS-E15, LNS-E29, LNS-E30, LNS-E31, LNS-E32, LNS-E33, LNS-E34	2) Restore/increase biodiversity	LNS-E10, LNS-E11, LNS-E12, LNS-E14a, b, LNS-E15, LNS-E29, LNS-E30, LNS-E31, LNS-E32, LNS-E33, LNS-E34
					3) Improvement of soil fertility through usage of organic fertilizers	LNS-F01, LNS-F02, LNS-F07
Food	1) Increase cost efficiency	LNS-E01, LNS-F05, LNS-01, LNS-S02, LNS-S03, LNS-S04	1) Increase cost efficiency	LNS-E01, LNS-F05, LNS-01, LNS-S02, LNS-S03, LNS-S04	1) Increase cost efficiency	LNS-E01, LNS-F05, LNS-01, LNS-S02, LNS-S03, LNS-S04
					2) Reduce food waste (manage good post-harvest practices)	LNS-E20
					3) Improvement of land productivity	LNS-F03

Table 17 Final list of NIs of Doñana Pilot.

Nexus Domain	Doñana	
	Objective	Related NIs
Water	1) Increase the irrigation water efficiency	LNS-W07: Water availability for irrigation purposes = 167 mio m^3/y
	2) Water allocation challenges/competition among sectors	LNS-W04 c: Share of Groundwater in Domestic Use = 6.06 mio m^3/y LNS-W05 c: Share of Groundwater in Industrial Use = 0.41 mio m^3/y
	1) Restore water quality	No NIs monitored
Ecosystem	1) Increase the annual flow to marshlands	LNS-E14a: Total surface area of wetlands = 53303 ha
	2) Increase the implementations of NBSs	No NIs monitored
	3) Restore/increase biodiversity	LNS-E14a: Total surface area of wetlands = 53303 ha
Food	1) Crop pattern change to increase drought resilience	LNS-W13: Water dependency for food production = 81.6 mio m^3

Table 18 Final list of NIs of Tarquinia Pilot Area.

Nexus Domain	Tarquinia	
	Objective	Related NIs
Water	1) Increase the irrigation water efficiency	LNS-W13: Water dependency for food production= 5.508.006 m^3 (2021)
		LNS-F06: Average irrigation water productivity= 9.46 €/m^3 (2021)
	2) Increase availability and sustainable management of irrigation water	LNS-W12a: Water price (Irrigation)= 0.35 €/m^3 (2022)
		LNS-W12c: Water price (Domestic)= 1.85 €/m^3 (2022)
		LNS-F06: Average irrigation water productivity= 9.46 €/m^3 (2021)
		LNS-E03: Mean annual temperature data= 17.13 °C (2022)
		LNS-E04: Mean annual precipitation data= 428 mm (2022)
	3) Restoring water quality	LNS-W26: Physico-chemical quality of surface waters= Poor
		LNS-W27: General ecological status of surface waters= Moderate
Ecosystem	1) Increase the implementations of NBSs	No NIs monitored
	2) Restore/increase biodiversity	LNS-E10: Designated areas= 27.52 km^2 (ZSC (SIC e ZPS))
		LNS-E14a: Total surface area of wetlands= 170 ha (Wet area Saline)
		LNS-E15: Agriculture: area under management practices potentially supporting biodiversity= %7.92 (2010)
		LNS-E32: Number of species within defined area=220 (bird species in salt area)
Food	1) Increase the agricultural infrastructure (tech)	No NIs monitored
	2) Increase cost efficiency	LNS-E01: Total population= 16075 (2022); 15942 (2023)
		LNS-S01: Farm Income per hectare=2000
		LNS-S02: Farmer Household Income= 63748
		LNS-S04: Farm input costs= 21500

PRIMA PARTNERSHIP FOR RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA
This project is part of the PRIMA programme supported by the European Union.
GA n° [2041] [LENSES] [Call 2020 Section 1 Nexus IA]

Table 19 Final list of NIs Koliaris Pilot Area.

Nexus Domain	Koiliaris	
	Objective	Related NIs
Water	1) Increase the irrigation water efficiency by irrigating the tree and not the field	LNS-W07: Water availability for irrigation purposes = 7000000 m^3/y
		LNS-W13: Water dependency for food production = 1200000 m^3
		LNS-F06: Average irrigation water productivity = 160 €/m^3
	2) Increase local stakeholder participation with governmental authorities to water management	LNS-S06: Local stakeholder participation in water resources management processes = 20 %
Ecosystem	1) Increase the implementations of NBSs	LNS-F07: Value of food produced by NBSs = 100 €/y
	2) Restore/increase biodiversity	LNS-E10: Designated areas = 26 km^2
		LNS-E11: Ecosystem coverage = 0 km^2
		LNS-E12: Fragmentation of natural and semi-natural areas = 0 %
		LNS-E14a: Total surface area of wetlands = 930 ha
		LNS-E14b: Surface area of restored and/or created wetlands = 0 ha
		LNS-E15: Agriculture: area under management practices potentially supporting biodiversity = 20 %
		LNS-E33: Total number and species richness of aquatic macroinvertebrates = NA
	3) Reduce the environmental pressures to ecosystems	LNS-E01: Total population = 12807 Capita
		LNS-E10: Designated areas = 26 km^2
		LNS-E11: Ecosystem coverage = 0 km^2
		LNS-E12: Fragmentation of natural and semi-natural areas = 0 %
		LNS-E14a: Total surface area of wetlands = 930 ha
		LNS-E14b: Surface area of restored and/or created wetlands = 0 ha
		LNS-E15: Agriculture: area under management practices potentially supporting biodiversity = 20 %
		LNS-E19: Polluted soils = 0 ha
		LNS-E20: Waste recycling rate = 25 %
		LNS-E22: Forest fires = 1
		LNS-E33: Total number and species richness of aquatic macroinvertebrates = NA
Food	1) Agroecological and NBS practices to increase food production	LNS-W13: Water dependency for food production = 1200000 m^3
		LNS-F01: Fertilizer use = 57.3 kg/ha
		LNS-F03: Average agricultural land productivity and profitability = 4000 €/ha (for olive trees as average)
		LNS-F06: Average irrigation water productivity = 160 €/m^3
		LNS-F07: Value of food produced by NBSs = 100 €/y
	3) Improve agricultural infrastructure (tech)	No NIs monitored

This project is part of the PRIMA programme supported by the European Union.
GA n° [2041] [LENSES] [Call 2020 Section 1 Nexus IA]

Table 20 Final list of NIs Pinios Pilot Area.

Nexus Domain	**Pinios**	
	Objective	Related NIs
Water	1) Improve water management and irrigation water use efficiency	AGIA: LNS-W07: Water availability for irrigation purposes=10000000 m^3/y, estimated according to long-term aquifer recharge and river water abstractions
		DELTA: LNS-W07: Water availability for irrigation purposes=12000000 m^3/y estimated according to long-term aquifer recharge
		AGIA: LNS-W13: Water dependency for food production= 6260357 m^3 /y, annual average for the period 1971-2000
		DELTA: LNS-W13: Water dependency for food production=7427444 m^3 /y, annual average for the period 1971-2000
		ESTIMATE, AGIA: LNS-W33: Leakage rate of the conveyance system=5%, closed pipe networks
		ESTIMATE, DELTA: LNS-W33: Leakage rate of the conveyance system=50%, for open canals and 5% closed pipe networks
		AGIA: LNS-F06: Average irrigation water productivity =3.3 €/m^3
		DELTA: LNS-F06: Average irrigation water productivity=1.2 €/m^3
	2) Improve groundwater quality issues posed mainly by locally high nitrate concentrations	AGIA: LNS-W17b: Nitrate in Groundwater; max=101 mg/L, average = 18.6 mg/L from 117 samples collected during the period 2017-2022
		DELTA: LNS-W17b: Nitrate in Groundwater; max=42.95 mg/L, average = 7.12 mg/L from 104 samples collected during the period 2013-2015
		AGIA: LNS-W21b min=6.8 max=8.2 average=7.4 from 117 samples collected during the period 2017-2022
		DELTA: LNS-W21b: Mean PH level of groundwater; min=6.15 max=8.14 average=7.52 from 104 samples collected during the period 2013-2015; AGIA: LNS-W23b: Metal concentration in groundwater=
		Zn (μg/L) max 185 average 35; Cu (μg/L) max 7,349 average 0.758; Fe (μg/L) max 538 average 24,779; Mn (μg/L) max 24.31 average 2,213; Pb (μg/L) max 2983 average 0.077; Ni (μg/L) max 21.44 average 1,588; Cd (μg/L) max 1,219 average 2,317; Cr (μg/L) max 12.19 average 2,317; As (μg/L) max 3342 average 0.653; Ba (μg/L) max 48.03 average 13,158; Tl (μg/L) max 1,084 average 0.246; Ag (μg/L) max 0.657 average 0.223; Sb (μg/L) max 2913 average 0.36; V (μg/L) max 3189 average 0.278; from 117 samples collected during the period 2017-2022
		DELTA: LNS-W23b: Metal concentration in groundwater=
		Cr (μg/L) max 34.53 average 4.56; Cu (μg/L) max 7.5 average 4.29; Fe (μg/L) max 14583 average 1691.88; Mn (μg/L) max 1609 average 261.9; Ni (μg/L) max 13.85 average 3.91; Zn (μg/L) max 8066.9 average 637.55; Cr (VI) (μg/L) max 19.3 average 6.61; from 104 samples collected during the period 2013-2015

Table 21 Final list of NIs Pinios Pilot Area (Continued).

Ecosystem	1) Increase the implementations of NBSs	AGIA: LNS-F07: Value of food produced by NBSs = 2191140 €/y based on the estimate that about 10% of the total income comes from fields that apply agroecological practices, such mulching/mowing
		DELTA: LNS-F07: Value of food produced by NBSs= 5171400 €/y based on the fact that irrigation of Alfalfa, Corn and Sunflower is reduced since a considerable amount of crop water requirements is satisfied by capillary rise
	2) Rational use of agricultural supplies and corresponding packaging	Not eligible for monitoring
	1) Restoration and conservation of the riparian habitats of the Pinios River including the maintenance of Pinios River environmental flow	AGIA: LNS-E01: Total population=5684, according to year 2021 census
		AGIA: LNS-E01: Total population=2848, according to year 2021 census
		AGIA: LNS-E10: Designated areas= 49.37 km^2 (76.43%)
		DELTA: LNS-E10: Designated areas= 37.63 km^2 (50.74%)
		AGIA: LNS-E11: Ecosystem coverage= 49.37 km^2 (76.43%) of protected areas
		DELTA: LNS-E11: Ecosystem coverage= 37.63 km^2 (50.74%) of protected areas and of which 4 km^2 are wetlands
		AGIA: LNS-E12: Fragmentation of natural and semi-natural areas= No changes were found according to the Corine Land Cover Change 2012-2018 https://land.copernicus.eu/en/products/corine-land-cover/lcc-2012-2018
		DELTA: LNS-E12: Fragmentation of natural and semi-natural areas= No changes were found according to the Corine Land Cover Change 2012-2018 https://land.copernicus.eu/en/products/corine-land-cover/lcc-2012-2018
		LNS-E18:Soil organic carbon= Total soil organic carbon content map of the pilot study area Soil Organic Carbon maps from SoilGrids are provided. Moreover, based on 215 samples collected on year 2020 in the plain area of Agia, the average soil organic carbon content was found to be 0.79%

Table 22 Final list of NIs Pinios Pilot Area (Continued).

<table>
<tr><td rowspan="10">Food</td><td rowspan="9">1) Crop pattern change and agricultural practices to increase extreme events resilience and maintain high agricultural productivity</td><td>LNS-W13: Total amount of water allocated to food producing agricultural irrigation=</td></tr>
<tr><td>AGIA: LNS-W13= 6260357 m^3 /y, annual average for the period 1971-2000</td></tr>
<tr><td>DELTA: LNS-W13=7427444 m^3 /y, annual average for the period 1971-2000</td></tr>
<tr><td>LNS-F01: Fertilizer use= average quantities according to the 1st Revision of Water Resources Management Plan of Thessaly Water District
<table>
<tr><th>Crop</th><th>N (kg/ha)</th><th>P2O5 (kg/ha)</th><th>K (kg/ha)</th><th>Mg (kg/ha)</th></tr>
<tr><td>Wheat</td><td>140</td><td>20</td><td>20</td><td>0</td></tr>
<tr><td>Corn</td><td>240</td><td>20</td><td>60</td><td>0</td></tr>
<tr><td>Cotton</td><td>175</td><td>70</td><td>70</td><td>70</td></tr>
<tr><td>Sunflower</td><td>90</td><td>70</td><td>70</td><td>0</td></tr>
<tr><td>Alfalfa</td><td>10</td><td>90</td><td>0</td><td>0</td></tr>
<tr><td>Apples</td><td>140</td><td>90</td><td>100</td><td>0</td></tr>
<tr><td>Kiwi fruit</td><td>200</td><td>90</td><td>275</td><td>0</td></tr>
</table></td></tr>
<tr><td>LNS-F02= Not feasible to monitor</td></tr>
<tr><td>AGIA: LNS-F06: Average irrigation water productivity =3.3 €/m^3</td></tr>
<tr><td>DELTA: LNS-F06: Average irrigation water productivity =1.2 €/m^3</td></tr>
<tr><td>AGIA: LNS-F07: Value of food produced by NBSs= 2191140 €/y based on the estimate that about 10% of the total income comes from fields that apply agroecological practices, such mulching/mowing</td></tr>
<tr><td>DELTA: LNS-F07: Value of food produced by NBSs= 5171400 €/y based on the fact that irrigation of Alfalfa, Corn and Sunflower is reduced since a considerable amount of crop water requirements is satisfied by capillary rise</td></tr>
<tr><td>2) Secure farmers' income against fluctuations of agricultural inputs costs and markets availability.</td><td>LNS-F04 Not feasible to monitor</td></tr>
</table>

Table 23 Final list of NIs Menemen Pilot Area.

Nexus Domain	Menemen	
	Objective	**Related NIs**
Water	1) Increase the irrigation water efficiency	LNS-W07: Water availability for irrigation purposes= 200 hm^3/y
		LNS-W13: Water dependency for food production= 1 hm^3/y
		LNS-F06: Average irrigation water productivity= Cotton: 0,47 €/m^3, Sunflower: 0,24 €/m^3, Wheat: 0,97 €/m^3.
	2) Reduction of leakages	No NIs monitored
	3) Desalination	LNS-E35: Soil electrical conductivity= 3,49 (0-30 depth)
	4) Recommending crop pattern according to water availability	LNS-E03: Mean annual temperature data= 17.9 °C (2022), 17.1 °C (1954-2022)
		LNS-E04: Mean annual precipitation data= 466.0 mm (2022), 544,7 mm (1954-2022)
		LNS-W06b: Share of Surface Water in Irrigation= 99%
		LNS-W02: Total Stored Surface Water= 300 hm^3
Ecosystem	1) Increase the implementations of NBSs	No NIs monitored
	2) Restore/increase biodiversity	LNS-E10: Designated areas= 400 ha
		LNS-E14a: Total surface area of wetlands= 194 ha
		LNS-E14b: Surface area of restored and/or created wetlands= N/A
		LNS-E15: Agriculture: area under management practices potentially supporting biodiversity= %1
		LNS-E30: Number of native species= 57.984 (Belonging to 54 waterfowl species)
		LNS-W17a: Nitrate in Surface waters= 1,69 mg N/l
		LNS-W20c: Mean PH level of water allocated to Irrigation Use= 7,89 pH (0-30 depth)
		LNS-W23a: Metal concentration in surface waters= N/A
		LNS-W26: Physico-chemical quality of surface waters= Good
		LNS-E18: Soil organic carbon= %0,98 (0-30 depth)
Food	1) Increase cost efficiency	LNS-E01: Total population= 78894 (2022 Census)
		LNS-S03: GDP per capita= 12269 €
		LNS-W12a: Price of water allocated to Irrigation Use=
		2022 year: Fruits, cotton, vineyard: 6,9 €/da. Maize, alfalfa, vegetables: 7,3 €/da. Olive: 4,5 €/da. Sunflower, cereals: 3,8 €/da. 2023 Year: Fruits, cotton, vineyard: 8,7 €/da. Maize, alfalfa, vegetables: 9,5 €/da. Olive: 5,9 €/da. Sunflower, cereals: 4,7 €/da.

This project is part of the PRIMA programme supported by the European Union.
GA n° [2041] [LENSES] [Call 2020 Section 1 Nexus IA]

Table 24 Final list of NIs Deir Alla Pilot Area.

Nexus Domain	Deir Alla	
	Objective	**Related NIs**
Water	1) Increase the irrigation water efficiency	LNS-W07: Water availability for irrigation purposes= 550 m^3/y
		LNS-W13: Water dependency for food production =50 m^3/month
		LNS-F06: Average irrigation water productivity = 1.2 €/m^3
	2) Increase the availability and sustainable management of irrigation water	LNS-W06b: Share of Surface Water in Irrigation = %95
		LNS-W06c: Share of Groundwater in Irrigation = %5
		LNS-W06d: Share of Treated Water in Irrigation = %30
		LNS-W07: Water availability for irrigation purposes= 550 m^3/y
		LNS-W11b: Groundwater Stress = <0.1
		LNS-W12a: Water Price = 0.15 €/m^3
		LNS-F06: Average irrigation water productivity = 1.2 €/m^3
		LNS-E03: Mean annual temperature data =30°C
		LNS-E04: Mean annual precipitation data=275 mm
	3) Desalination	LNS-E35: Soil electrical conductivity (EC)= 3.5 mS/m
Ecosystem	1) Increase the implementations of NBSs	LNS-F07: Value of food produced by NBSs= 600€/y
		LNS-E25: Soil erosion= 0.05 m^3
	2) Restore/increase biodiversity	LNS-E10: Designated areas = N/A
		LNS-E12: Fragmentation of natural and semi-natural areas = %7.5
		LNS-E30: Number of native species= 8
		LNS-E32: Number of species within defined area= 5
	3) Improvement of soil fertility through usage of organic fertilizers	LNS-F01: Fertilizer use= 100 kg/ha
		LNS-F02: Pesticide use= 5 kg/ha
Food	1) Increase cost efficiency	LNS-E01: Total population= 50000 Cap.
		LNS-F05: Cost risks= %5
		LNS-S01= Average income yield per hectare in the pilot study area = 12000 €
		LNS-S02: Farmer Household Income= 12000 €
		LNS-S04: Farm input costs= 4300 €
	2) Reduce food waste (manage good post-harvest practices)	LNS-E20: Waste recycling rate= N/A
		LNS-F04: Employment in agriculture= 1 No./ha
	3) Improvement of land productivity	LNS-F03: Average agricultural land productivity and profitability= 7000 €/ha
		LNS-S06: Local stakeholder participation in water resources management processes= %80

8. Conclusions

This deliverable advances the understanding of Nexus systems, emphasizing the interplay between socio-economic and ecological factors. Through participatory approaches integrated with SDM, key challenges, strategic objectives, and barriers to sustainable Nexus management are identified. The focus on ES-based analysis and socio-ecological networks provides a comprehensive perspective for guiding effective decision-making in pilot areas.

In abstract, the analysis of the Doñana and Tarquinia pilot areas as an example in this deliverable, helps describing the structure of socio-ecological networks and identify key barriers to the production of ecosystem services (ESs) in the context of the water-ecosystem-food Nexus. Both regions face challenges stemming from conflicts among stakeholders, a lack of coordination, limited awareness, and limited financial sources within the communities. The identified barriers, ranging from institutional conflicts to social capital deficits, reveal the need for integrated and collaborative approaches to address the complex challenges within these socio-ecological systems.

Participatory System Dynamics Modelling (PSDM) tools, such as Causal Loop Diagrams (CLDs), provide a valuable support for visualizing and understanding the dynamics, and facilitating the discussion with stakeholders. These models can guide the formulation of targeted interventions and policies that promote sustainable resource management, resilience, and the equitable provision of ecosystem services in the face of evolving environmental and societal challenges. As detailed in the D4.2, the LENSES project proposes a comprehensive and participatory approach to address the complex challenges within the water-ecosystem-food (WEF) nexus across diverse pilot areas, using PSDM. Through extensive stakeholder engagement, bilateral meetings, questionnaires and semi-structured interviews, the project identifies common WEF challenges among the pilot areas, such as water scarcity, degraded water and soil quality, and issues related to intensive agriculture. These challenges serve as the foundation for establishing Nexus Domain Objectives (DOs) tailored to each pilot. The DOs cover water, ecosystem, and food domains and are refined throughout the project based on participatory processes, stakeholder workshops, and modelling activities.

The evaluation of progress and achievement of DOs is facilitated by Nexus Indicators (NIs), providing a comprehensive and multidimensional assessment that extends beyond the core domains to include energy, socio-economy, climate change, and gender equality. This approach also enables the understanding and identification of Nexus Resilience Qualities (NRQs), encompassing socio-economic and legislative infrastructures, awareness, training, technology, and institutional structures that contribute to the resilience of WEF Nexus environments. NRQs are identified and retained for further improvement, acknowledging their role in supporting adaptive capacity to Nexus challenges and objectives.

The recommended NIs encompass a range of objectives, such as increasing irrigation water efficiency, managing water allocation challenges, implementing Nature-Based Solutions (NBSs) to restore biodiversity, and promoting sustainable agricultural practices. These objectives align with the specific needs and characteristics of each pilot area, acknowledging the diversity in environmental, social, and economic contexts. While progress has been made in selecting and adopting indicators, it is essential to highlight the challenges faced in monitoring certain indicators, especially those deemed immeasurable or ineligible due to data restrictions. This situation underlies the importance of ongoing collaboration, research, and technological advancements to overcome these limitations and ensure a comprehensive understanding of the nexus dynamics. Therefore, the required but unavailable NIs for each pilot area provide a roadmap for future actions for monitoring and data gathering for stakeholders and policymakers in order to have a clearer understanding of WEF Nexus. The ongoing monitoring and evaluation of these NIs will be crucial to track progress, adapt strategies, and refine interventions, ultimately contributing to the achievement of a balanced and sustainable nexus in the face of local and global challenges.

In conclusion, the work presented in this deliverable enabled the understanding and addressing the complex interdependencies within the water-ecosystem-food nexus across various pilot areas, namely Doñana, Tarquinia, Koiliaris, Pinios, Menemen and Deir Alla. Unfortunately, Hula Valley's contribution has been limited due to current circumstances occurring in the Middle East region. Through data analysis, stakeholder engagement, and PSDM exercises, the project has identified some available or measurable key indicators (NIs) for each pilot, and these indicators continuous monitoring will aid to detect and enhance sustainability, resource efficiency, and ecosystem health in selected pilot areas. Furthermore, the methodology and progress achieved in pilot areas can be extended to various areas across the EU and associated countries facing similar Nexus challenges.

9. References

Bodin, Ö. (2017). Collaborative environmental governance: Achieving collective action in social-ecological systems. Science, 357(6352). https://doi.org/10.1126/science.aan1114

Calliari, E., Michetti, M., Farnia, L., & Ramieri, E. (2019). A network approach for moving from planning to implementation in climate change adaptation: Evidence from southern Mexico. Environmental Science & Policy, 93, 146–157. https://doi.org/10.1016/j.envsci.2018.11.025

Chandra, R., & Uniyal, V. P. (2021). Assessment of Local Adaptive Capacity of Mountain Farmers: A Way Forward for Sustainable Livelihood Development. Asia-Pacific Journal of Rural Development, *31*(2), 172–194. https://doi.org/10.1177/10185291211069753

Cumming, G. S., Olsson, P., Chapin, F. S., & Holling, C. S. (2013). Resilience, experimentation, and scale mismatches in social ecological landscapes. Landscape Ecology, 28, 1139–1150.

Dee, L. E., Allesina, S., Bonn, A., Eklöf, A., Gaines, S. D., Hines, J., Jacob, U., McDonald-Madden, E., Possingham, H., Schröter, M., & Thompson, R. M. (2017). Operationalizing Network Theory for Ecosystem Service Assessments. Trends in Ecology & Evolution, 32(2), 118–130. https://doi.org/10.1016/j.tree.2016.10.011

EEA (2022). European Environmental Agency. Indicators, https://www.eea.europa.eu/ims, Accessed: March 2022.

Engle, N. L. (2011). Adaptive capacity and its assessment. Global Environmental Change, 21, 647–656.

Folke, C. (2016). Resilience (republished). Ecology and Society, *21*(4), 44.

Giordano, R., Manez-Costa, M., Pagano, A., Mayor Rodriguez, B., Zorrilla-Miras, P., Gomez, E., & Lopez-Gunn, E. (2021). Combining social network analysis and agent-based model for enabling nature-based solution implementation: The case of Medina del Campo (Spain). Science of the Total Environment, 801, 149734. https://doi.org/10.1016/j.scitotenv.2021.149734

Guimarães L.T., & Magrini, A. (2008). A proposal of indicators for sustainable development in the management of river basins. Water Resour Manag., 22, 1191–1202.

Harmancioglu, N. B. (2004). Indicators for sustainable management of water resources (in Turkish). In: Proceedings of IV. National hydrology congress. ITU, Istanbul, 9–18.

Pahl-Wostl, C. (2019). Governance of the water-energy-food security nexus: A multi-level coordination challenge. Environmental Science and Policy, 92, 356–367. https://doi.org/10.1016/j.envsci.2017.07.017

Simane, B., Zaitchik, B. F., & Foltz, J. D. (2014). Agroecosystem specific climate vulnerability analysis: Application of the livelihood vulnerability index to a tropical highland region. Mitigation and Adaptation Strategies for Global Change, 21, 39–65.

Smit, B., & Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. Global Environmental Change, 16, 282–292.

UNESCO (2022). United Nations Educational, Scientific and Cultural Organisation. Indicators. https://unesdoc.unesco.org/ark:/48223/pf0000371562 Accessed: March 2022.

Walmsley, J. J. (2002). Framework for measuring sustainable development in catchment systems. Environ Manag *29*(2), 195–206.

WB (2022). World Bank. Indicators, https://data.worldbank.org/indicator, Accessed: March 2022.

Weitz, N., Strambo, C., Kemp-Benedict, E., & Nilsson, M. (2017). Closing the governance gaps in the water-energy-food nexus: Insights from integrative governance. Global Environmental Change, 45, 165–173. https://doi.org/10.1016/j.gloenvcha.2017.06.006

Annex 1 "Nexus Indicators (NIs)"

Table A1.1 Water domain dominant NIs

Domain*	Indicator Code	Indicator Name	Definition	Rationale	Methodology	Unit	Extent	
							Spatial	Tempor
W	LNS-W01	River Flow Discharge	Observed river flow discharges related to pilot study area	River flow discharges represent one of the main inputs of water budget in the examined hydrologic cycle and are essential for the assessment of water budget.	Observed Data	m^3/sec	Basin	Daily
W	LNS-W02	Total Stored Surface Water	Total amount of stored surface water in different types of natural and man-made reservoirs such as dams, weirs, lake, etc.	One of the key elements to water budget assessment	Observed Data	m^3	Basin	Daily
W	LNS-W03	Groundwater Potential	Total amount of available groundwater in the basin	One of the key elements to water budget assessment	Observed Data	m^3	Basin	Annual
W	LNS-W04b	Share of Surface Water in Domestic Use	Percentage of surface water allocated to domestic use in the pilot	Indicator of water resources exploitation and element to water budget assessment	Observed Data (Total volume of surface water allocated to domestic use in pilot study area / Total volume of water allocated to domestic use in pilot study area)	%	Pilot	Annual

W	LNS-W04c	Share of Groundwater in Domestic Use	Percentage of groundwater allocated to domestic use in the pilot	Indicator of water resources exploitation and element to water budget assessment	Observed Data (Total volume of groundwater allocated to domestic use in pilot study area / Total volume of water allocated to domestic use in pilot study area)	%	Pilot	Annual
WE	LNS-W04a	Share of Treated Sea Water in Domestic Use	Percentage of treated sea water allocated to domestic use in the pilot	Indicator of water resources exploitation and element to water budget assessment	Observed Data (Total volume of treated sea water allocated to domestic use in pilot study area / Total volume of water allocated to domestic use in pilot study area)	%	Pilot	Annual
WE	LNS-W04d	Share of Treated Water in Domestic Use	Percentage of treated water allocated to domestic use in the pilot	Indicator of water resources exploitation and element to water budget assessment	Observed Data (Total volume of treated water allocated to domestic use in pilot study area / Total volume of water allocated to domestic use in pilot study area)	%	Basin	Daily
WE	LNS-W05a	Share of Treated Sea Water in Industrial Use	Percentage of treated sea water allocated to industrial use in the pilot	Indicator of water resources exploitation and element to water budget assessment	Observed Data (Total volume of treated sea water allocated to industrial use in pilot study area / Total volume of water allocated to domestic use in pilot study area)	%	Basin	Daily
W	LNS-W05b	Share of Surface Water in Industrial Use	Percentage of surface water allocated to industrial use in the pilot	Indicator of water resources exploitation and element to water budget assessment	Observed Data (Total volume of surface water allocated to industrial use in pilot study area / Total volume of water allocated to domestic use in pilot study area)	%	Basin	Daily
W	LNS-W05c	Share of Groundwater in Industrial Use	Percentage of groundwater allocated to industrial use in the pilot	Indicator of water resources exploitation and element to water budget assessment	Observed Data (Total volume of groundwater allocated to industrial use in pilot study area / Total volume of water allocated to domestic use in pilot study area)	%	Basin	Daily
W	LNS-W08	Measured or calculated infiltration rate and capacity	Measured or calculated infiltration rate and capacity of pilot study area, can be provided as a map if the rate and capacity is significantly varied	One of the key elements to water budget assessment	Observed Data	% or mm/h and mm/d	Basin	Annual

WE	LNS-W05d	Share of Treated Water in Industrial Use	Percentage of treated water allocated to industrial use in the pilot	Indicator of water resources exploitation and element to water budget assessment	Observed Data (Total volume of treated water allocated to industrial use in pilot study area / Total volume of water allocated to domestic use in pilot study area)	%	Basin	Daily
WE	LNS-W09	Evapotranspiration rate	Observed Evapotranspiration rate of the pilot study area, can be provided as a map if the rate is significantly varied	One of the key elements to water budget assessment	Observed Data	mm/m^2 day	Basin	Daily
WE F	LNS-W06a	Share of Treated Sea Water in Irrigation	Percentage of treated sea water allocated to irrigation use in the pilot	Indicator of water resources exploitation and element to water budget assessment	Observed Data (Total volume of treated sea water allocated to irrigation use in pilot study area / Total volume of water allocated to domestic use in pilot study area)	%	Basin	Daily
WE F	LNS-W06d	Share of Treated Water in Irrigation	Percentage of treated water allocated to irrigation use in the pilot	Indicator of water resources exploitation and element to water budget assessment	Observed Data (Total volume of treated water allocated to irrigation use in pilot study area / Total volume of water allocated to domestic use in pilot study area)	%	Basin	Daily
WF	LNS-W06b	Share of Surface Water in Irrigation	Percentage of surface water allocated to irrigation use in the pilot	Indicator of water resources exploitation and element to water budget assessment	Observed Data (Total volume of surface water allocated to irrigation use in pilot study area / Total volume of water allocated to domestic use in pilot study area)	%	Basin	Daily
WF	LNS-W06c	Share of Groundwater in Irrigation	Percentage of groundwater allocated to irrigation use in the pilot	Indicator of water resources exploitation and element to water budget assessment	Observed Data (Total volume of groundwater allocated to irrigation use in pilot study area / Total volume of water allocated to domestic use in pilot study area)	%	Basin	Daily
WF	LNS-W07	Water availability for irrigation purposes	Annual total amount of water reserved for irrigation purposes in the pilot study area by the basin water resources management bodies	Indicator of water resources exploitation and element to water budget assessment	Observed Data	m^3/y	Pilot	Annual

This project is part of the PRIMA programme supported by the European Union.
GA n° [2041] [LENSES] [Call 2020 Section 1 Nexus IA]

W	LNS-W10	Calculated drinking water provision	Total amount of water allocated to Domestic Use	Indicator of water resources exploitation and element to water budget assessment	Observed Data	$m^3/ha/y$	Pilot	Monthly
W	LNS-W11a	Water Stress	Water withdrawal as a proportion of available water resources	Water Stress/Exploitation is considered to be; low: <0.1, moderate: 0.1-0.2, medium: 0.2-0.4, high: >0.4	Index (Total freshwater withdrawal in pilot study area / Total available freshwater resource in pilot study area) Raskin P, Gleick P, Kirshen P, Pontius G and Strzepek K 1997 Comprehensive Assessment of the Freshwater Resources of the World: Report of the Secretary General United Nations Economic and Social Council, Commission on Sustainable Development Online: http://www.un.org/ga/search/view_doc.asp?symbol=E/CN.17/1997/9&Lang=E	Unitless	Pilot	Annual
W	LNS-W11b	Groundwater Stress	Water withdrawal as a proportion of available water resources					
W	LNS-W11c	Water Exploitation Index	Mean annual total demand for surface/ground water divided by the long-term average surface/ground water resources in the pilot study area					
W	LNS-W11d	Groundwater Exploitation Index	Mean annual total demand for surface/ground water divided by the long-term average surface/ground water resources in the pilot study area					
WF	LNS-W12a	Water Price	Price of water allocated to Irrigation Use	Indicator of water and food security	Observed Data	€/m^3	Pilot	Monthly
W	LNS-W12b		Price of water allocated to Industrial Use	Indicator of water security	Observed Data	€/m^3	Pilot	Monthly

W	LNS-W12c		Price of water allocated to Domestic Use	Indicator of water security	Observed Data	€/m^3	Pilot	Monthly
WF	LNS-W13	Water dependency for food production	Total amount of water allocated to food producing agricultural irrigation	Indicator of water productivity	Observed Data	m^3	Pilot	Monthly
WE	LNS-W14	Turbidity of Surface waters	This provides the amount of fine particulate in the water. Turbidity is defined as the degree to which light is scattered by particles suspended in a liquid. There are several different units for turbidity depending on the wave length of the light source and the incident angle. Nephelometric turbidity units (NTU) are based on white light (400–680 nm) and 90° incident angle.	Turbidity of surface waters related to pilot study area	Observed Data	NTU	Basin	Monthly
WE	LNS-W15a	River Water Temperature	Observed mean temperature of the river related to pilot study area	Indicator of Biodiversity and water quality	Observed Data	°C	Basin	Monthly
WE	LNS-W15b	Lake Water Temperature	Observed mean temperature of the natural/man-made lakes related to pilot study area	Indicator of Biodiversity and water quality	Observed Data	°C	Basin	Daily

WE	LNS-W16	Groundwater chemical status	Chemical status of groundwater according to; For EU countries: EU Water Framework Directive (WFD); For non-EU countries: National WFD	Indicator of groundwater quality	Observed Data	Good or Poor	Basin	Annual
WE	LNS-W17a	Nitrate in Surface waters	Observed Nitrate content in the surface water resources related to pilot study area	Indicator of water quality	Observed Data	mg N/l	Basin	Daily
WE	LNS-W17b	Nitrate in Groundwater	Observed Nitrate content in the groundwater resources related to pilot study area	Indicator of water quality	Observed Data	mg N/l	Basin	Daily
WE	LNS-W18a	Phosphate in Surface waters	Observed Phosphate content in the surface water resources related to pilot study area	Indicator of water quality	Observed Data	mg P/l	Basin	Daily
WE	LNS-W18b	Phosphate in Groundwater	Observed Phosphate content in the groundwater resources related to pilot study area	Indicator of water quality	Observed Data	mg P/l	Basin	Daily
WE	LNS-W19	Organic/inorganic micropollutants observed in surface water sediment (Bioindicators)	Organic/inorganic micropollutants observed in surface water sediment samples (Bioindicators) (Heavy Metals, PAHs, Chlorinated hydrocarbon pesticides, Polychlorinated byphenyls (PCBs))	Indicator of water quality	Observed Data	mg/kg	Basin	Daily

This project is part of the PRIMA programme supported by the European Union.
GA n° [2041] [LENSES] [Call 2020 Section 1 Nexus IA]

WE	LNS-W20a	Mean pH level of water allocated to Domestic Use	Mean pH level of water allocated to Domestic Use in pilot study area	Indicator of water quality	Observed Data	pH	Basin	Daily
WE	LNS-W20b	Mean PH level of water allocated to Industrial Use	Mean PH level of water allocated to Industrial Use in pilot study area	Indicator of water quality	Observed Data	pH	Basin	Daily
WE	LNS-W20c	Mean PH level of water allocated to Irrigation Use	Mean PH level of water allocated to Irrigation Use in pilot study area	Indicator of water quality	Observed Data	pH	Basin	Daily
WE	LNS-W21a	Mean PH level of surface waters	Mean PH level of surface waters in pilot study area	Indicator of water quality	Observed Data	pH	Basin	Daily
WE	LNS-W21b	Mean PH level of groundwater	Mean PH level of groundwater in pilot study area	Indicator of water quality	Observed Data	pH	Basin	Daily
WE	LNS-W22	Total Suspended Solids (TSS) content of surface waters	Total suspended solids (TSS) are defined as solids in water that can be trapped by a filter. To measure TSS, the water sample is filtered through a pre-weighed filter. The residue retained on the filter is dried in an oven at 103–105°C until the weight of the filter no longer changes. The increase in weight of the filter represents the TSS.	Indicator of water quality	Observed Data	%	Basin	Monthly

This project is part of the PRIMA programme supported by the European Union.
GA n° [2041] [LENSES] [Call 2020 Section 1 Nexus IA]

WE	LNS-W23a	Metal concentration in surface waters	The concentration of heavy metals found in the water resources/allocated waters in the pilot study area	Indicator of water quality	Observed Data	%	Basin	Monthly
WE	LNS-W23b	Metal concentration in groundwater	The concentration of heavy metals found in the water resources/allocated waters in the pilot study area	Indicator of water quality	Observed Data	%	Basin	Monthly
WE	LNS-W24	Metal concentration in waters allocated to Domestic Use	The concentration of heavy metals found in the water resources/allocated waters in the pilot study area	Indicator of water quality	Observed Data	%	Basin	Monthly
WE	LNS-W25	Eutrophication	Eutrophication in pilot study area water bodies according to; For EU countries: EU Water Framework Directive (WFD); For non-EU countries: National WFD	Indicator of water quality	Observed Data	Unitless	Pilot	Annual
WE	LNS-W26	Physico-chemical quality of surface waters	Physico-chemical quality of surface waters in pilot study area according to; For EU countries: EU Water Framework Directive (WFD); For non-EU countries: National WFD	Indicator of water quality	Observed Data	High, Good, Moderate, Poor, Bad	Pilot	Annual
WE	LNS-W27	General ecological status of surface waters	Ecological status of surface waters in pilot study area according to; For EU countries: EU Water Framework Directive (WFD); For non-EU countries: National WFD	Indicator of water quality	Observed Data	High, Good, Moderate, Poor, Bad	Pilot	Annual

This project is part of the PRIMA programme supported by the European Union.
GA n° [2041] [LENSES] [Call 2020 Section 1 Nexus IA]

WE	LNS-W28	Ecological potential for heavily modified or artificial water bodies	Ecological potential for heavily modified or artificial water bodies in pilot study area according to; For EU countries: EU Water Framework Directive (WFD); For non-EU countries: National WFD	Indicator of water quality	Observed Data	Maximum, Good, Moderate, Poor, Bad	Pilot	Annual
WE	LNS-W29	Biological quality of surface waters	Biological quality of surface waters in pilot study area according to; For EU countries: EU Water Framework Directive (WFD); For non-EU countries: National WFD	Indicator of water quality	Observed Data	High, Good, Moderate, Poor, Bad	Pilot	Annual
WE	LNS-W30	Hydromorphological quality of surface waters	Hydromorphological quality of surface waters in pilot study area according to; For EU countries: EU Water Framework Directive (WFD); For non-EU countries: National WFD	Indicator of water quality	QUALPHY method	Unitless	Pilot	Annual
WE	LNS-W31a	BOD5 concentration in treated sea waters	Observed BOD5 content in various water resources	Indicator of water quality	Observed Data	mg BOD5/l	Pilot	Monthly
WE	LNS-W31b	BOD5 concentration in surface waters	Observed BOD5 content in various water resources	Indicator of water quality	Observed Data	mg BOD5/l	Pilot	Monthly
WE	LNS-W31c	BOD5 concentration in groundwater	Observed BOD5 content in various water resources	Indicator of water quality	Observed Data	mg BOD5/l	Pilot	Monthly
WE	LNS-W31d	BOD5 concentration in treated waters	Observed BOD5 content in various water resources	Indicator of water quality	Observed Data	mg BOD5/l	Pilot	Monthly

WE	LNS-W32a	Chlorophyll content in treated sea waters	Observed Chlorophyll content in various water resources	Indicator of water quality	Observed Data	mg Chl/l	Pilot	Monthly
WE	LNS-W32b	Chlorophyll content in surface waters	Observed Chlorophyll content in various water resources	Indicator of water quality	Observed Data	mg Chl/l	Pilot	Monthly
WE	LNS-W32c	Chlorophyll content in groundwater	Observed Chlorophyll content in various water resources	Indicator of water quality	Observed Data	mg Chl/l	Pilot	Monthly
WE	LNS-W32d	Chlorophyll content in treated waters	Observed Chlorophyll content in various water resources	Indicator of water quality	Observed Data	mg Chl/l	Pilot	Monthly
WS	LNS-W33	Leakage rate of the conveyance system	Leakage rate of the conveyance system in the pilot study area	Indicator of irrigation efficiency	Observed Data	%	Pilot	Annual
WE	LNS-W34	Total amount of water allocated to wetlands	Environmental flow allocated to wetlands	Indicator of ecosystem, biodiversity	Observed Data	m^3	Pilot	Annual

**Domain initials listed represent; W: Water, E: Ecosystem, F: Food, S: Socio-Economic, En: Energy, CC: Climate Change, G: Gender Equality*

Table A1.2 Ecosystem domain dominant NIs

Domain*	Indicator Code	Indicator Name	Definition	Rationale	Methodology	Unit	Extent	
							Spatial	Temporal
ES	LNS-E01	Total population	Total population residing in the pilot study area	Indicator of ecosystem pressures	Observed Data	Capita	Pilot	Annual
ES	LNS-E02	Total economically active population in agriculture	Total population active in agricultural economy	Indicator of ecosystem pressures	Observed Data	Capita	Pilot	Annual
WE	LNS-E03	Mean annual temperature data	Observed mean annual temperature data in the pilot study area	Climate data provides a time series of weather variables record.	Observed Data	°C	Pilot	Annual
WE	LNS-E04	Mean annual precipitation data	Observed mean annual precipitation data in the pilot study area	Climate data provides a time series of weather variables record.	Observed Data	mm	Pilot	Annual
WE	LNS-E05	Soil moisture	Soil moisture map of the pilot study area	Soil moisture is of critical importance to the physical processes governing energy and water exchanges at the land/air boundary	Observed Data	Litres/ m^3/y	Pilot	Annual
WE	LNS-E06	Surface reflectance - Albedo	Total daily surface reflectance - Albedo of the pilot study area	Importance of the indicator comes with the climate change and vegetation	Observed Data	Unitless	Pilot	Annual

This project is part of the PRIMA programme supported by the European Union.
GA n° [2041] [LENSES] [Call 2020 Section 1 Nexus IA]

WE	LNS-E07	Snow cover	Snow cover content map of the pilot study area	Snow influences the climate and climate-related systems because of its high reflectivity, insulating properties, effects on water resources and ecosystems, and cooling of the atmosphere. A decrease in snow cover accelerates climate change.	Observed Data	%	Pilot	Annual
WE	LNS-E08	Local sea-level rise	Local sea-level rise amount relative to long-term local sea-level	It is an important indicator of climate change, with great relevance in the pilot area for flooding, coastal erosion and the loss of flat coastal regions. Rising sea levels increase the likelihood of storm surges, enforce landward intrusion of salt water and endanger coastal ecosystems and wetlands.	Observed Data	Meters	Pilot	Annual
WE	LNS-E09	Sea surface temperature (SST)	This indicator monitors trends in average SST anomalies in local seas.	Sea surface temperature (SST) affects species' metabolism, distribution and phenology, with many marine species and habitats being highly sensitive to changes in SST. Increases in mean SST can also lead to increases in atmospheric water vapour over the oceans, influencing entire weather systems.	Observed Data	°C	Pilot	Annual
E	LNS-E10	Designated areas	The indicator shows the proportion of a country designated total area that is protected under either the EC Birds and/or Habitats Directives, or by national instruments, or by both.	The establishment of protected areas is a direct response to concerns over biodiversity loss, so an indicator that measures protected area coverage is a valuable indication of commitment to conserving biodiversity and reducing biodiversity loss at a range of levels.	Observed Data	km^2	Basin	Annual

E	LNS-E11	Ecosystem coverage	Proportional and absolute change in the extent and turnover of land cover categories aggregated to relate to MAES ecosystem types.	It indicates the area of available habitats and ecosystems in the pilot study area. If an area decreases drastically it will have a negative influence on the species dependent on that habitat. In that sense this indicator is particularly important for specialist species and endemic species that are dependent on particular habitats in the ecosystem and cannot survive in other ecosystems.	Observed Data	km²	Basin	Annual
E	LNS-E12	Fragmentation of natural and semi-natural areas	Change in the proportion of core natural/semi natural lands that are cut to pieces by urban sprawl together with a rapidly expanding transport network, urbanisation, agriculture and/or artificial lands.	It indicates changes in the patch size of natural and semi-natural areas of any type of ecosystem in the pilot study area. If the patch size of these areas decreases drastically it will have a negative influence on the habitat types present and the species dependent on these habitat types.	Observed Data	%	Basin	Annual
E	LNS-E13a	Forest areas - Growing stock, increment and fellings	The volume of growing forest	Growing stock is a traditional indicator of sustainability of the forest sector and is also used as a proxy for biodiversity. The sustainable development of growing stock in forests and other wooded land, through the comparison of fellings and net annual increment is evaluated on the basis of long-term available data for all pan-European countries.	Observed Data	m³/ha, %	Basin	Annual
E	LNS-E13b	Forest areas - Deadwood	The volume of standing and lying deadwood in forest and other wooded land, classified by forest type	Deadwood is a measure of habitat quality relevant for thousands of forest organisms, several of which are threatened. Data on deadwood can be collected at relatively low cost in national forest inventories and the indicator is reported by countries according to agreed definitions.	Observed Data	m³/ha	Basin	Annual

WE	LNS-E14a	Total surface area of wetlands	Total surface area of wetlands in pilot study area	The indicator has a high relevance for biodiversity because it indicates the area of available habitats and ecosystems across Europe	Observed Data	ha	Pilot	Annual
WE	LNS-E14b	Surface area of restored and/or created wetlands	Total surface area of restored and/or created wetlands in the pilot study area	The indicator is relevant for the change of biodiversity and ecosystem.	Observed Data	ha	Pilot	Annual
EF	LNS-E15	Agriculture: area under management practices potentially supporting biodiversity	Share of High Nature Value farming land (organic farming) to the total utilised agricultural area	The mere presence of HNV farmland is not proof of sustainable management but promoting conservation and sustainable farming practices in these areas is crucial for biodiversity.	Observed Data	%	Pilot	Annual
EF	LNS-E16	Fisheries: Commercial fish stocks	Annual trend in release of nutrients into the marine environment as a result of fishery practices.	Shows a real risk of biodiversity loss.	Observed Data	Tonnes	Pilot	Annual
WEF	LNS-E17	Aquaculture: effluent water quality from finfish farms	Annual trend in release of nutrients into the marine environment as a result of aquaculture practices.	Data availability on production levels and average values for conversion factors.	Observed Data	Tonnes	Pilot	Annual
EF	LNS-E18	Soil organic carbon	Total soil organic carbon content map of the pilot study area	Low levels of organic carbon in the soil are generally detrimental to soil fertility, water retention capacity and resistance to soil compaction. Increases in surface water run-off can lead to erosion while lack of cohesion in the soil can increase the risk of erosion by wind. Other effects of lower organic carbon levels are a reduction in biodiversity and an increased susceptibility to acid or alkaline conditions	Observed Data	%	Pilot	Annual

This project is part of the PRIMA programme supported by the European Union.
GA n° [2041] [LENSES] [Call 2020 Section 1 Nexus IA]

E	LNS-E19	Polluted soils	Total area of polluted soil in pilot study area according to; For EU countries: EU Soil Policy; For non-EU countries: National Soil Policies	The indicator tracks progress in the management of contaminated sites and the restriction of land use and use of ground/surface water, and in the provision of public and private money for remediation.	Observed Data	ha	Pilot	Annual
E	LNS-E20	Waste recycling rate	Percentage of recycled solid waste	Indicating progress towards using more waste as a resource and achieving a circular economy	Observed Data	%	Pilot	Annual
WEF	LNS-E21	Ecological Footprint	Survey results of ecological footprint presented by the Global Footprint Network for evaluation	Indicating the overall resource demand of the pilot study area compared with resource availability in Europe and the rest of the world.	Survey Data	%	Pilot	Annual
E	LNS-E22	Forest fires	Recorded number of forest fire events observed in the pilot study area	Indicating the hazard risk observed in the pilot study area	Observed Data	Number	Pilot	Annual
WE	LNS-E23	Long-term historical storm event data	Long-term historical storm event data observed in the pilot study area	Indicating the hazard risk observed in the pilot study area	Observed Data	mm	Pilot	Hourly
WE	LNS-E24	Long-term historical flood event data	Long-term historical flood event data observed in the pilot study area	Indicating the hazard risk observed in the pilot study area	Observed Data	m^3	Pilot	Hourly

WEF	LNS-E25	Soil erosion	Total amount of soil detached and removed by water and/or wind form the pilot study area	By removing fertile topsoil, erosion reduces soil productivity and, where soils are shallow, may lead to the loss of the entire soil body. Erosion can lead to restrictions on land use and land value, damage to infrastructure, pollution of water bodies, and negative effects on habitats and biodiversity.	Observed Data	m^3	Pilot	Monthly
WE	LNS-E26	Streamflow Drought Index (SDI)	Uses monthly streamflow values and the methods of normalization associated with SPI for developing a drought index based upon streamflow data. With an output similar to that of SPI, both wet and dry periods can be investigated, as well as the severity of these occurrences.	Indicating the hazard risk observed in the pilot study area	Nalbantis and Tsakiris, 2009	Unitless	Pilot	Monthly
WE	LNS-E27	Morphological Quality Index (MQI)	Morphological Quality Index (MQI) of the main river reach in the pilot study area	MQI has been specifically designed to assess the environmental impact assessment of interventions, including both flood mitigation and restoration actions by evaluating additional sub-set of indicators defined in the index methodology	Rinaldi et al., 2012	Unitless	Pilot	Annual
WE	LNS-E28	Fluvial Functionality Index (FFI)	Fluvial Functionality Index (FFI) of the main river reach in the pilot study area	The main objective of the index consists of the overview of the comprehensive state of the river environment and in the evaluation of its functionality, understood to be the result of synergy and the integration of an important series of biotic and abiotic factors present in the water ecosystem and in the connected terrestrial one.	Siligardi, M. et al., 2000	Unitless	Pilot	Annual

E	LNS-E29	Red List Index for European species	Index relates to the proportion of species expected to remain extant in the near future in the absence of additional conservation action.	Highly relevant as a measure of the state of biodiversity, relating to the rate at which species are slipping towards extinction, and to the proportion of species expected to remain extant in the near future in the absence of additional conservation action.	Observed Data	Unitless	Basin	Annual
E	LNS-E30	Number of native species	Total number of native animal species	Indicating the state of biodiversity in the pilot study area	Observed Data	Number	Pilot	Annual
E	LNS-E31	Number of invasive alien species	Total number of invasive alien animal species	Indicating the state of biodiversity in the pilot study area	Observed Data	Number	Pilot	Annual
E	LNS-E32	Number of species within defined area	Total number animal species in the pilot study area	Indicating the state of biodiversity in the pilot study area	Observed Data	Number	Pilot	Annual
E	LNS-E33	Total number and species richness of aquatic macroinvertebrates	Total number and species richness of aquatic macroinvertebrates observed in the pilot study area	Indicating the water quality level by their effect on dissolved oxygen, nutrient and pH levels.	Observed Data	Unitless	Pilot	Annual
E	LNS-E34	Species diversity within defined area (Shannon diversity Index)	Shannon Diversity Index of the pilot study area to measure the diversity of species.	Indicating the number of species living in a habitat (richness) and their relative abundance (evenness). The higher the value of index will indicate the higher the diversity of species in the pilot study area.	Observed Data	Number	Pilot	Annual
E	LNS-E35	Soil electrical conductivity (EC)	EC is a measure of salts in soil and an indicator of nutrient availability and loss, soil texture	Indicating soil salination condition	Observed Data	mS/m	Pilot	Annual

**Domain initials listed represent; W: Water, E: Ecosystem, F: Food, S: Socio-Economic, En: Energy, CC: Climate Change, G: Gender Equality*

Table A1.3 Food domain dominant NIs

Domain*	Indicator Code	Indicator Name	Definition	Rationale	Methodology	Unit	Extent	
							Spatial	Temporal
EF	LNS-F01	Fertilizer use	Total amount of fertilizer used in the pilot study area	Indicating the positive affect on food production while negative affect on ecosystem.	Observed Data	kg/ha	Pilot	Annual
EF	LNS-F02	Pesticide use	Total amount of pesticides used in the pilot study area	Indicating the positive affect on food production while negative affect on ecosystem.	Observed Data	kg/ha	Pilot	Annual
F	LNS-F03	Average agricultural land productivity and profitability	Average agricultural land income yield per hectare in pilot study area	Indicating the agricultural land profitability	Observed Data	€/ha	Pilot	Annual
F	LNS-F04	Employment in agriculture	Total number of employees in agriculture in the pilot study area per hectare	Indicating the agriculture sector size	Observed Data	No./ha	Pilot	Annual
F	LNS-F05	Cost risks	Cost risks experienced in the agricultural production procedure	Indicating the risks of breakage, leftover product, decay/rot	Observed Data	%		

WF	LNS-F06	Average irrigation water productivity	Average income yield in the pilot study area per cubic meter of irrigation water	Indicating the water productivity	Observed Data	€/m^3	Pilot	Annual
EF	LNS-F07	Value of food produced by NBSs	Total income yield of food produced by the NBS practices in the pilot study area	Indicating the good farming practice volume	Observed Data	€/y	Pilot	Annual
F	LNS-F08	Agricultural export subsidies	Total governmental support provided to agricultural product exportation	Indicating the governmental support on food production	Observed Data	€/y	Pilot	Annual
F	LNS-F09	Indicator of food price anomalies (IFPA)	The indicator of food price anomalies (IFPA) identifies market prices that are abnormally high. The IFPA relies on a weighted compound growth rate that accounts for both within year and across year price growth. The indicator directly evaluates growth in prices over a particular month over many years, considering seasonality in agricultural markets and inflation, allowing to answer the question of whether or not a change in price is abnormal for any particular period.	Indicating the food security	https://unstats.un.org/sdgs/metadata/files/Metadata-02-0C-01.pdf	Unitless	Pilot	Annual
Domain initials listed represent; W: Water, E: Ecosystem, F: Food, S: Socio-Economic, En: Energy, CC: Climate Change, G: Gender Equality								

Table A1.4 Socio-economy domain dominant NIs

Domain*	Indicator Code	Indicator Name	Definition	Rationale	Methodology	Unit	Extent	
							Spatial	Temporal
S	LNS-S01	Farm Income per hectare	Average income yield per hectare in the pilot study area	Indicating the socio-economic status of the agricultural community in the study area	Observed Data	€/ha	Pilot	Annu
S	LNS-S02	Farmer Household Income	Farmers average household income in the pilot study area	Indicating the socio-economic status of the agricultural community in the study area	Observed Data	€	Pilot	Annu
S	LNS-S03	GDP per capita	GDP of the pilot area	Indicating the socio-economic status of the agricultural community in the study area	Observed Data	€/No.	Pilot	Annu
SEnF	LNS-S04	Farm input costs (Fertilizer, Pesticide, Herbicide, Labour, Electricity, Water, etc. cost listed by crop type)	Various cost types listed by the crop types	Indicating the socio-economic status of the agricultural community in the study area	Observed Data	€	Pilot	Annual
S	LNS-S05	International tourism (thousand arrivals)	Total amount of international tourists visiting the pilot study area	Indicating the socio-economic status of the agricultural community in the study area	Observed Data	Number	Pilot	Annual
SW	LNS-S06	Local stakeholder participation in water resources management processes	Percentage of local stakeholders' participation in water resources management processes	Indicating sustainable management of water resources	Observed Data	%	Pilot	Annua
SW	LNS-S07	Water resources themed training and capacity building events held in pilot	Number of events held in pilot study area concerning water resources for local communities	Indicating sustainable management of water resources	Observed Data	Number	Pilot	Annual
SWEFEn	LNS-S08	Status of agricultural infrastructure	Rating of agricultural infrastructure state between 1 - 10 on expert opinion	Indicating the state of art condition of agricultural infrastructure	Surveyed Data	Number	Pilot	Annu

**Domain initials listed represent; W: Water, E: Ecosystem, F: Food, S: Socio-Economic, En: Energy, CC: Climate Change, G: Gender Equality*

Table A1.5 Energy domain dominant NIs

Domain*	Indicator Code	Indicator Name	Definition	Rationale	Methodology	Unit	Extent	
							Spatial	Temporal
EnSF	LNS-En01	Electricity Cost	Electricity cost of the pilot area	Indicating the socio-economic challenges, food security	Observed Data	€	Pilot	Annual
EnSF	LNS-En02	Share of Electricity costs in Agriculture	Electricity cost of the agricultural community	Indicating the socio-economic challenges, food security	Observed Data	%	Pilot	Annual
EnE	LNS-En03	Share of renewable energy in gross final energy consumption	Ratio of renewable energy consumption to total energy consumption	Indicating the ecosystem friendly practices, sustainability	Observed Data	%	Pilot	Annual
EnS	LNS-En04	Energy productivity	Income yield per kW	Indicating the sustainability, energy efficiency	Observed Data	€/kW	Pilot	Annual

**Domain initials listed represent; W: Water, E: Ecosystem, F: Food, S: Socio-Economic, En: Energy, CC: Climate Change, G: Gender Equality*

Table A1.6 Climate change domain dominant NIs

Domain*	Indicator Code	Indicator Name	Definition	Rationale	Methodology	Unit	Extent	
							Spatial	Temporal
CCEF	LNS-CC01	Carbon removed or stored in vegetation and soil	Total carbon consumed by the vegetation and soil in pilot study area	The indicator represents the carbon sequestration capacity of the pilot area	Observed Data	kg/ha/y	Pilot	Annual
CCE	LNS-CC02	Carbon storage and sequestration in vegetation per unit area per unit time	Total carbon consumed by the vegetation in pilot study area	The indicator represents the carbon sequestration capacity of the vegetation in the pilot area	Observed Data	kg/ha/y	Pilot	Annual
CCE	LNS-CC03	Monthly mean value of daily maximum temperature	Maximum value of daily maximum temperature	The indicator represents the climate change effects on the pilot study area	Observed Data	°C	Pilot	Daily
CCE	LNS-CC04	Monthly mean value of daily minimum temperature	Maximum value of daily minimum temperature	The indicator represents the climate change effects on the pilot study area	Observed Data	°C	Pilot	Daily
CCE	LNS-CC05	Total Leaf Area	Total leaf area of the pilot study area	The indicator represents the canopy coverage of the pilot study area	Observed Data	ha	Pilot	Annual
CCE	LNS-CC06	Soil Temperature	Observed soil temperature (as a map or time-series)	The indicator represents the climate change effects on the pilot study area	Observed Data	°C	Pilot	Annual

This project is part of the PRIMA programme supported by the European Union.
GA n° [2041] [LENSES] [Call 2020 Section 1 Nexus IA]

CCSE	LNS-CC07	Mean annual direct and indirect losses due to natural and climate hazards	This indicator considers the number of fatalities, and the overall and insured economic losses from natural and climate-related disasters.	Global weather and climate-related disaster losses reported over the last few decades mainly reflect monetised direct damages to assets and are unequally distributed.	Observed Data	€	Pilot	Annual
CCS	LNS-CC08	Multi-hazard early warning	Does the pilot study area have installed multi-hazard early warning systems?	The indicator represents the natural disaster readiness of the pilot study area	Observed Data	Yes/No	Pilot	Annual
CCS	LNS-CC10	Insurance against catastrophic events	Percentage of the insured agricultural businesses	The indicator represents the natural disaster readiness of the pilot study area	Observed Data	%	Pilot	Annual
CCE	LNS-CC11	Share of areas associated with landslides	Percentage of landslide risk areas in the pilot study area	The indicator represents the natural disaster risk of the pilot study area	Observed Data	ha	Pilot	Annual
CCE	LNS-CC12	Share of area under extreme drought based on SPI	Percentage of area classified as "extreme drought" according to SPI	The indicator represents the natural disaster risk of the pilot study area	Observed Data	ha	Pilot	Annual
CCE	LNS-CC13	Erosion risk	Amount of soil lost to erosion process	Excess water due to intense or prolonged precipitation can cause tremendous damage to soil. Sheet-wash, rill and gully development can strip the topsoil from the land, thus effectively destroying the capability of the soil to provide economic or environmental services	Observed Data	m^3/year	Pilot	Annual
CCE	LNS-CC14	Total Predicted Soil Loss	Amount of soil predicted to be lost to erosion	The indicator represents the natural disaster risk of the pilot study area	Observed Data	t/ha/y	Pilot	Annual
CCE	LNS-CC15	Effective drought index	Time-series or map of Effective drought index of the pilot study area	The indicator represents the natural disaster risk of the pilot study area	Observed Data	Unitless	Pilot	Annual

**Domain initials listed represent; W: Water, E: Ecosystem, F: Food, S: Socio-Economic, En: Energy, CC: Climate Change, G: Gender Equality*

Table A1.7 Gender equality domain dominant NIs

Indicator Code	Indicator Name	Definition	Rationale	Methodology	Unit	Extent	
						Spatial	Temporal
LNS-G01	Number of local woman Presence	Presence and role of local women's groups/organizations/self-help groups receiving technical and/or financial support from government/non-government organizations for managing local drinking water or irrigation schemes.	Indicator of gender-responsive management	Observed Data	Number	Pilot	Annual
LNS-G02	Rate of F/M in the workplace	Number of Female/Male (F/M) staff in different job positions (levels), job field, and salaries (scales) in(a) governmental institutions, and (b) in public/private utilities and commissions for water-related services.	Indicator of gender-responsive management	Observed Data	%	Pilot	Annual
LNS-G03	Rate of F/M in agricultural land ownership	Number of irrigated and non-irrigated farms, with size and type of F/M land ownership rights and tenure, in the survey area or region.	Women's land ownership and/or control is critical to achieving the economic dimension of gender equality, since land ownership gives rise to a host of benefits for women through an increase in their bargaining power within households and the economy	Observed Data	%	Pilot	Annual
LNS-G04	Rate of F/M in irrigation sector	Number of F/M holders of irrigation water rights in formal surface and groundwater irrigation schemes	Indicator of gender-responsive implementation of water programmes	Observed Data	%	Pilot	Annua
LNS-G05	Women's Access to Financial Services	F/M access to sources of formal and informal credit (banks, cooperatives, self-help groups, social networks, moneylenders, etc.) for improving irrigation, including rainwater harvesting measures	Indicator of access to irrigation	Observed Data	%	Pilot	Annual

This project is part of the PRIMA programme supported by the European Union.
GA n° [2041] [LENSES] [Call 2020 Section 1 Nexus IA]

LNS-G06	Male-Female Wage Differentials	F/M wage labour, by crop and season, in irrigated and non-irrigated or rainfed agriculture in the area of study (farm level or community level) with respective tasks and wages	Indicator of gender wage difference in agriculture sector	Observed Data	%	Pilot	Annual
LNS-G07	Women ownership of water related industries	Number of large- and small-scale water-related industries and enterprises managed/owned by F/M.	Indicator of gender-responsive management	Observed Data	Number	Pilot	Annual
LNS-G08	Reports of discrimination	Reports of discrimination by sex and cultural, or any other identity (physical, social or economic), in access to water supply and sanitation by location/neighbourhood/community.	Indicator of gender-responsive management	Observed Data	Number	Pilot	Annual
LNS-G09	F/M level of satisfaction regarding water availability	Level of satisfaction of F/M consumers regarding quantity and quality of water available from piped water supply to the household, disaggregated by geographical location within the study area.	Indicator of availability, affordability, acceptability and quality of water for F/M consumers	Observed Data	Unitless	Pilot	Annual
LNS-G10	Social, physical and economic impact of water scarcity on household members	Social, physical and economic impact on household members disaggregated by sex and age when the quantity of water is not sufficient for drinking/domestic use; source of water (piped water/common or shared source); and reasons for insufficiency of water.	Indicator of availability, affordability, acceptability and quality of water for F/M consumers	Observed Data	Unitless	Pilot	Annual
LNS-G11	F/M rate of availability, accessibility and affordability	Level of availability, accessibility and affordability of/to water source for F/M who are differently abled, in migrant and displaced populations, refugee camps and shelters, Indigenous Peoples, ethnic minorities, by location/ neighbourhood/community/displacement or refugee settings.	Indicator of availability, affordability, acceptability and quality of water for F/M consumers	Observed Data	Unitless	Pilot	Annual
LNS-G12	Rate of F/M traditional knowledge	F/M traditional knowledge, practices and roles in water management	Indicator of F/M traditional knowledge, practices and roles in water management	Observed Data	%	Pilot	Annual
LNS-G13	Rate of F/M in gender sensitization trainings	Number of F/M staff/employees in different job positions participating in gender-sensitive/responsive training events in (a) national ministries that deal with water resources, (b) in public/private utilities and commissions for water-related services, (c) water-related industry and enterprise; feedback on the usefulness of the training from F/M staff/employees.	Indicator of gender sensitization trainings	Observed Data	%	Pilot	Annual

Annex 2 “Data Availability Survey”

Table A2.1 Data availability survey

No.	Requested Data
1	Water temperature data (river and lakes)
2	Total Renewable Freshwater Resources (m^3/year)
3	Total irrigated agriculture area (ha in pilot)
4	Total Freshwater Withdrawn (m^3/year)
5	Total crop production in pilot (in kg per crop type)
6	Total amount of water abstracted from wells to drinking water supply networks (m^3/year)
7	Total amount of water abstracted from wells to agricultural irrigation networks (m^3/year)
8	Total amount of water abstracted from springs to drinking water supply networks (m^3/year)
9	Total amount of water abstracted from springs to agricultural irrigation networks (m^3/year)
10	Total amount of water abstracted from rivers to drinking water supply networks (m^3/year)
11	Total amount of water abstracted from rivers to agricultural irrigation networks (m^3/year)
12	Total amount of water abstracted from lakes to drinking water supply networks (m^3/year)
13	Total amount of water abstracted from lakes to agricultural irrigation networks (m^3/year)
14	Total amount of water abstracted from dams to drinking water supply networks (m^3/year)
15	Total amount of water abstracted from dams to agricultural irrigation networks (m^3/year)
16	Total agricultural area (ha in pilot)
17	The number of local administrative units on water and sanitation management
18	Soil Moisture Data
19	Size of special protection and designated areas for terrestrial and freshwater biodiversity (km^2)
20	Rate of population served by water supply network in total pilot population (%)
21	Quantity of water in water-related ecosystems and inland open waters (m^3/year)
22	Quality of water in water-related ecosystems and inland open waters (m^3/year)
23	Proportion of land that is degraded over total land area in pilot (km^2)
24	Proportion of bodies of water with good ambient water quality
25	Population plant species (near threatened, vulnerable, endangered, critically endangered)
26	Population of bird species (near threatened, vulnerable, endangered, critically endangered)
27	Population mammal species (near threatened, vulnerable, endangered, critically endangered)
28	Population fish species (near threatened, vulnerable, endangered, critically endangered)
29	Number of water-related natural disasters (floods and droughts)
30	Number of water-borne disease cases
31	Number of food-borne disease cases
32	Number and condition of endemic species
33	Life losses from water-related natural disasters
34	Legislative/released environmental flow rates (%)
35	Kilograms per hectare of arable land in pilot
36	Industrial wastewater discharges
37	Fertilizer input data in agriculture (kg/ha)
38	Environmental Flow Requirement (m^3/year)
39	Economic losses from water-related natural disasters
40	Daily precipitation data
41	Daily max min temperature data
42	Crop price (in local currency per crop type)
43	Crop pattern distribution (%)

Table A2.1 Data availability survey (Continued).

44	Crop and vegetation phenology data
45	Average amount of water abstracted per capita per day (liters/capita-day)
46	Area of water-related ecosystems and inland open waters
47	Area of transboundary river basins with operational water cooperations in pilot (km^2)
48	Area of transboundary river basins in pilot (km^2)
49	Area of transboundary lake basins with operational water cooperations in pilot (km^2)
50	Area of transboundary lake basins in pilot (km^2)
51	Area of transboundary aquifer basins with operational water cooperations in pilot (km^2)
52	Area of transboundary aquifer basins in pilot (km^2)
53	Annual mean concentrations of phosphorus in lakes in pilot
54	Annual mean concentrations of phosphate in rivers in pilot
55	Annual mean concentrations of nitrate in rivers in pilot
56	Annual mean concentrations of nitrate in groundwater in pilot
57	Amount of water distributed via drinking water supply network (m^3/year)
58	Amount of water distributed via agricultural irrigation network (m^3/year)
59	Amount of treated water used in industry (m^3/year)
60	Amount of treated water used in agriculture (m^3/year)
61	Amount of treated water used for recreational purposes (m^3/year)
62	Amount of treated water used for drinking and domestic purposes (m^3/year)
63	Agriculture Share of Government Expenditure (in local currency)
64	Agriculture Share of GDP (in local currency)
65	Agricultural area under productive and sustainable agriculture in the pilot (ha)

This project is part of the PRIMA programme supported by the European Union.
GA n° [2041] [LENSES] [Call 2020 Section 1 Nexus IA]

Annex 3 "Nexus Resilience Qualities (NRQs)"

Table A3.1 Nexus Resilience Qualities (NRQs)

	Domain	Name	Definition
Economic Resources	S	Diversity of source of income	Revenue streams that are independent of each other will promote socio-economic resilience in a hazard event where sources of income might be temporarily or permanently unavailable
	S	Remittance	Transfer of money by a foreign worker
	S	Access to credits	Ability of individuals or enterprises to obtain financial credits
	S	Labour and time	Meeting labour demand
Social Capital	S	Access to family labour	Labour force without or with little payment
	WEF	Participation in agri-based organisation	Agricultural community's organisation extensity
	WEF	Participation in development-based organisation	Local community's organisation extensity
	S	Local Networks	Local community's network extensity
	SW	Trust in Government	The share of people who report having confidence in the national government.
	S	Reciprocity	The practice of exchanging things with others for mutual benefits
Awareness &Training	WEF	Knowledge & acceptance of climate change	Helping a better understanding of the future effects of the climate
	WEF	Literacy	Promoting the lifelong learning about agriculture
	WEF	Access to agri-based information	Promotes positive effects on agriculture
	WEF	Experience	Past information and living of events of the environment
	WEF	Formal & informal training	Training based and practical learning
Technology	WEF	Seed variety	Cultivating various seeds promotes the biodiversity and ecosystem resilience
	WEF	Soil moisture	Soil moisture promotes ecosystem, lower irrigation dependence and higher food production
	WEF	Soil fertility	Soil fertility promotes ecosystem, lower irrigation dependence and higher food production
	WF	Farm mechanization	Farm mechanization promotes higher food production yield and lower agricultural input dependence
	W	Rainwater harvesting	Rainwater harvesting promotes lower irrigation dependence
	E	Eco-friendly techniques	Eco-friendly techniques promote ecosystem
	WEF	Innovation	Innovation promotes development and efficiency of processes

This project is part of the PRIMA programme supported by the European Union.
GA n° [2041] [LENSES] [Call 2020 Section 1 Nexus IA]

Table A3.1 Nexus Resilience Qualities (NRQs) (continued).

Infrastructure	WEF	Land holding size	Land holding size can prevent agricultural land fracturing, thus efficient use of agricultural land. Yet on the other hand, larger land holding sizes can threaten biodiversity due to often practiced single crop type cultivation
	WEF	Land ownership	Land ownership ratio in the pilot indicates the freedom of decision-making
	W	Irrigation facilities	Established irrigation facilities provide irrigation reliability and accessibility and water security
	EF	Road	Roads provide accessibility to inputs required in the WEF Nexus
	F	Access to market	Access to market provides food security and socio-economic development
	F	Processing & storage unit	Processing & storage unit provides food security
Institution	WF	Access to subsidy	Payments by the government to producers of agricultural products for the purpose of stabilizing food prices, ensuring plentiful food production, guaranteeing farmers' basic incomes, and generally strengthening the agricultural segment of the national economy.
	WF	Access to relief	After a hazard, access to relief provides socio-economic security
	WEF	Governance system	System by which an organisation is controlled and operates, and the mechanisms by which it, and its people, are held to account.
	WEF	Adaptive management	A structured approach to decision making that emphasizes accountability and explicitness in decision making
	WEF	Risk behaviour	Liberty to take risks to implement new ideas
	WEF	Water Governance	The political, social, economic and administrative systems in place that influence water's use and management

This project is part of the PRIMA programme supported by the European Union.
GA n° [2041] [LENSES] [Call 2020 Section 1 Nexus IA]