A SOCIO-ECOLOGICAL APPROACH TO COMBAT DESERTIFICATION FOR SUSTAINABLE FUTURE

EcoFuture

Work Package Number 1

Deliverable 1.4 NBS bundles analysis for WEFE priorities

Author(s): Shiri Zemah-Shamir (RUNI), Emmanuelle Cohen-Shacham (RUNI), Oren Shapir (RUNI), Geula Bitton (RUNI), Nikolaos Nikolaidis (TUC), Maria Lilli (TUC), David Lehrer (AIES), Michael Gilmont (AIES), Suleiman A. Halasah (iGreens), Jozsef Kadar (AIES)

September 2024

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

Project no. 2243

Project acronym: EcoFuture

Project title: A socio-ecological approach to combat desertification for a sustainable future

Call: PRIMA Call 2022 Section 1 NEXUS WEFE IA

Start date of project: 01.04.2023

Duration: 36 months

Deliverable title: NBS bundles analysis for WEFE priorities

Due date of deliverable: 30.09.2024

Project Coordinator: Nikolaos Nikolaidis

Organisation name of lead contractor for this deliverable: Technical University of Crete (TUC)

Lead Authors Emmanuelle Cohen-Shacham, Shiri Zemah-Shamir, Oren Shapir

Email shiri.zemahshamir@runi.ac.il

Contributions from Geula Bitton, Nikolaos Nikolaidis, Maria Lilli, David Lehrer, Michael Gilmont, Suleiman A. Halasah, Jozsef Kadar

Internal Reviewer 1 Nikolaos Nikolaidis

Internal Reviewer 2 Maria Lilli

Dissemination level			
PU	**Public/ Confidential**		**PU**
History			
Version	**Date**	**Reason**	**Revised by**
01	30.08.2024	Draft	Emmanuelle Cohen-Shacham and Shiri Zemah-Shamir
02	27.09.2024	Final	Nikolaos Nikolaidis and Maria Lilli
03			
04			
05			

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

Table of Contents

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

List of figures

List of tables

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

Executive Summary

The EcoFuture project aims to develop a comprehensive climate-change adaptation program that enhances socio-economic welfare in the Mediterranean Region through the application of the Water-Energy-Food-Ecosystem (WEFE) Nexus methodology. Task 1.4 specifically focuses on identifying and proposing bundles of Nature-based Solutions (NbS) to address critical challenges within pilot sites and the broader Jordan Valley (JV) Region, which is characterised by water scarcity, land degradation, and extreme climatic events.

NbS are interventions that protect, manage, and restore ecosystems, providing solutions to societal challenges such as climate change mitigation and adaptation, ensuring water and food security, and reversing biodiversity loss. In the JV Region, NbS bundles aim to optimize water management, energy efficiency, food production, and ecosystem health, creating synergies across sectors to improve long-term socio-economic stability.

The project faces significant challenges due to the region’s ecological conditions, including intermittent resource availability, water shortages, droughts, low soil fertility, and desertification, as well as human pressures such as increased population growth and increased infrastructures to support it. The differing environmental management practices between Jordan, Palestine, and Israel present additional complexity. While Israel benefits from advanced water management technologies, Jordan and Palestine face more severe water scarcity and underdeveloped infrastructure.

The core objective of Task 1.4 is to establish a methodology for selecting relevant NbS interventions adapted to the WEFE Nexus. This involved stakeholder consultations and a systematic review of literature to map and prioritize challenges in the region creating compendium of NbS interventions. The selected NbS bundles will play a crucial role in enhancing water security, food production, and ecosystem resilience in the JV, ensuring a more sustainable and adaptable future for the region amidst the growing impacts of climate change.

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

1. Introduction

The Ecofuture project's main objective is to develop a climate-change adaptation program to improve socio-economic welfare for people in the Mediterranean region, while being based on the Water-Energy-Food-Ecosystem (WEFE) Nexus methodology. Task 1.4 focuses on the Nature-based Solutions (NbS) bundles to be identified and proposed for addressing the most important challenges in the pilots and the Jordan Valley (JV) as a whole, in the WEFE Nexus context. The four elements of WEFE are the cornerstones of long-term socio-economic stability and can therefore be considered as the foundation for human well-being (Vanino et al., 2024). It is therefore important to identify the region's challenges, define NbS bundles and understand the important role they play in addressing the challenges relevant to the WEFE Nexus in the JV Region.

1.1 What are Nature-based Solutions?

Nature-based Solutions (NbS) are actions to protect, manage and restore natural or modified ecosystems, which address societal challenges, effectively and adaptively, providing human well-being and biodiversity benefits (International Union for the Conservation of Nature - IUCN, 2016). They play a crucial role in addressing a number of interrelated societal challenges, such as addressing climate change and biodiversity loss, or ensuring water security and food security.

These solutions can be employed independently or in conjunction with engineering solutions, to enhance their effectiveness (Cohen-Shacham et al., 2016; Seddon et al, 2020). *NbS bundles* refer to different NbS interventions that are combined to tackle multiple challenges within the WEFE Nexus (Maragkaki et al., 2024; Lili et al., 2024). These bundles are specifically designed to optimize the interconnected aspects of water management, energy security, food production and ecosystem health in a given area. The aim is to create a synergistic effect that addresses several environmental and resource management challenges simultaneously.

NbS are particularly valuable in Mediterranean, semi-arid and arid type regions, where water scarcity and extreme climatic events are prevalent. Implementing NbS can help sustainably manage water resources, reduce the impact of extreme weather, while enhancing the resilience of communities for adaptation to climate change and ensuring their socio-economic development. Through the integration of NbS in local, national and regional planning, we can ensure a more sustainable future for these vulnerable regions (Canals Ventín and Lázaro Marín, 2019).

The JV, like other dryland regions, struggles with significant ecological challenges such as intermittent resources availability, low soil fertility, chronic water shortages, and ongoing desertification, all of which adversely affect the livelihoods of local communities (Hadadin et al., 2022). Ecosystems in this area are particularly vulnerable to human-induced climate changes. Recent studies, such as those conducted in the Wadi Al-Arab catchment area, highlight the impacts of climate change on water resources, showing reductions in precipitation and significant increases in temperature, which further exacerbate water scarcity and land degradation issues (Hadadin et al., 2022).

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

The ecosystems located in the Jordanian, Palestinian and Israeli parts of the Jordan Valley, while geographically close and sharing many natural landscapes, show distinct differences due to varying environmental management practices, resource availability, and technological development. Both jurisdictions (Jordan and Palestine) rely on **aquatic ecosystems**, particularly the Jordan River, which serves as a crucial water source and supports biodiversity. However, Israel's investment in advanced water management technologies, such as irrigation systems and desalination, enables more efficient use of water resources. In contrast, Jordan struggles with greater water scarcity and less developed infrastructure, which makes it harder to sustain its aquatic environments.

Agricultural ecosystems also differ significantly between the three regions. In Israel, sophisticated irrigation techniques have transformed even arid areas into productive farmland, allowing a broad range of crops to be grown. On the Jordanian and Palestinian side, agriculture is more dependent on traditional irrigation systems, which are more vulnerable to water shortages, affecting crop yields and the stability of agricultural productivity.

All jurisdictions (Israel, Jordan and Palestine) host **dryland ecosystems**, but the role they play varies from one place to another. Israel places a strong focus on investment in drylands research and management, aimed at preserving desert vegetation and adapting to extreme arid conditions. In contrast, reforestation projects and afforestation initiatives have created managed **open green spaces** in Israel, such as **Mediterranean forests**, which are a key part of its environmental strategy. In Jordan, drylands are represented by the **Hammada vegetation**, which includes plants adapted to harsh desert conditions. Less investment in desert conservation or reforestation projects is undertaken, compared to Israel, primarily due to resource constraints.

Although **blue spaces** such as the Jordan River are similarly critical to all three jurisdictions, their management approaches differ. Israel focuses on enhancing water conservation and maintaining aquatic ecosystems health through various water management strategies. Jordan, particularly in the northern part of the JV, faces significant challenges related to water resource management, due to infrastructure constraints, despite ongoing efforts to improve water use efficiency (Kosel et al., 2020; Boulad et al., 2021). These differences highlight the importance of **Nature-Based Solutions** (NbS) in addressing shared environmental challenges across the Jordanian, Palestinian, and Israeli parts of the Jordan Valley, as such approaches offer sustainable methods for managing water resources, enhancing agricultural productivity, and preserving dryland ecosystems, while promoting cross-border cooperation and ecological resilience despite varying resource and technological capacities.

1.2 Objective of this task and report

The objective of Task 1.4 was to provide the methodological and practical foundations for the selection of a suite of NbS type interventions to propose and implement in a WEFE Nexus approach in the JV. For this, we reviewed and analyzed the NbS interventions that could potentially be relevant - in the relevant ecological and geographic contexts and to address relevant challenges - and implemented both in the pilots and in the JV as a whole. We identified the potential role of NbS for addressing the relevant challenges, for a resilient WEFE Nexus in the JV. In this report, we are presenting all the information that was gathered.

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

2. Methodology

We initially aimed at gathering information on the challenges to be addressed and the NbS to be identified, prioritized and proposed, based on stakeholders semi-structured interviews and workshops. But due to the ongoing war in the region, the unavailability of stakeholders to participate in online interviews or attend workshops, and the impossibility to have multi-countries gatherings as previously planned, we developed another method to collect the information.

The method we used in this task was partly based on the evaluation framework developed in the H2020 ThinkNATURE and PRIMA LENSES projects. The challenges relevant to the region and the relevant NbS types were identified and selected, based on the WEF Nexus Evaluation Framework (Vanino et al., 2024).

Then we conducted a systematic literature review of both scientific and grey literature, based on the PRISMA the Preferred Reporting Items for Systematic reviews and Meta-Analyses protocol), to map out and collect all relevant information on NbS that are relevant to address the challenges in the pilots and in the JV as a whole. The PRISMA protocol includes three stages: (1) systematic article selection applying a search engine, (2) bibliographic sources screening, and (3) review of selected articles with information extraction.

We conducted the bibliographic search using the Scopus database, while selecting the following search terms in the title, abstract, or keywords:

1. Keywords reflecting various **types of NbS interventions**: "Nature based Solution* OR Nature-based Solution* OR Ecological restoration OR Ecological engineering OR Blue infrastructure OR Green infrastructure OR Ecosystem-based adaptation OR Ecosystem-based mitigation OR Ecosystem-based disaster risk reduction OR Agroecologic*"
2. Keywords reflecting **relevant societal challenges**: water AND (security OR scarcity) OR food OR food security OR climate change OR Global warming OR biodiversity loss OR ecosystem* degradation OR human health OR disaster risk red* OR economic development OR social development.
3. Keywords reflecting the **relevant climatic regions**: Mediterranean OR arid OR semi-arid.

We only selected articles and review articles in the list, and only kept publications in English. The final result of selected publication changed from 586 to 574 results, from which we carefully looked into titles, keywords, abstracts, and we removed the irrelevant articles from the list. We were left with 160 articles to be reviewed by the research team (the data collected from 108 of these articles is presented in the report).

To ensure that a consistent literature analysis was undertaken among the different team members, we then developed and refined an online questionnaire in the format of Google Form (see Table 1 below), and we piloted one article to ensure that all fields were properly understood and consistently analysed. The outcomes of the literature review are presented in Part 4 of the current document.

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

Table 1: Main information collected in online Google form, from each reviewed article

Broad category	Information collected
Details on reviewer & publication	Team member, articles title, author, DOI
Relevancy of article	Is the publication relevant to this literature review? If not, provide reason(s) for irrelevancy
Publication type	Article / review article
Geographic characteristics	Scale, region, specify jurisdiction (Israel, Jordan or Palestine, or specify)
Ecological and climate characteristics	Climate type(s), ecosystem type(s),
Relevant challenges addressed by NbS	Societal challenges, SDGs
NbS type	Specific NbS type, description of solution in detail, main co-benefits addressed by NbS
Relevant links to WEFE	Additional links/synergies between NbS and Water, Energy, Food, or Ecosystem; Additional issues relevant to the project / region

3. Major societal challenges that can be addressed by NbS and review of environmental & societal challenges relevant to the Jordan Valley

According to the IUCN, there are seven major societal challenges that NbS aim at addressing (IUCN, 2016; IUCN, 2020a):

- **Climate change**, through ecosystem-based adaptation or ecosystem-based mitigation;
- **Biodiversity loss and ecosystem degradation** – given the important location of the JV in terms of biodiversity, and the number of different ecosystems relevant to the area, it is important to conserve the region's biodiversity and ecosystem;
- **Ensuring Disaster risk reduction**, such as fires, flooding, through ecosystem-based disaster risk reduction;
- **Ensuring water security**, both taking into account the quantity and quality;
- **Ensuring food security,** taking into account both quality and quantity, through the development and implementation of approaches such as agroecosystems;
- **Ensuring human health**. This is often more relevant in the urban context, but which may also be relevant in the JV as a results of issues such as air, soil or water pollution;

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

- **Ensuring Economic and Social development** – During its planning and implementation, NbS are to take into account community needs as to possible social development and creation of jobs.

To identify the environmental challenges specifically relevant to the JV, we used the results of Tasks 1.1, 1.2 and 1.3. Within Task 1.1, a WEFE (Water, Energy, Food, Ecosystem) Nexus resources mapping was conducted, and the following issues /elements were identified as with highest priority to address in the JV:

3.1 Water security

Water deficit – The agricultural water uses account for 91% of the total water supply, where 16% is used for aquaculture and 75% for irrigation. The irrigation rates range from 385 mm/dunum for Israel to 677 mm/dunum for Jordan and 360 mm/dunum for Palestine. The differences in irrigation rates are due to water losses/leakages in the network that is estimated to be about 30% for Jordan and 50% for Palestine (EcoFuture Deliverable 1.1). If we account for water losses in the distribution network in Jordan and Palestine, only half of this water reaches the consumers. In addition, the reuse of treated wastewater is very low in Palestine. On the other hand, the demand for both drinking and agricultural water use is quite significant in Jordan and especially in Palestine (where only a small fraction of the agricultural land is irrigated), creating a significant deficit between supply and demand.

Water quality – The available water supply in the JV has been impacted by high water salinity levels due to geogenic causes. In addition, the main sources of anthropogenic pollution in the JV are wastewater from treatment plants and unsewered areas, fertilizer, pesticide and herbicide pollution from agriculture, urban solid waste disposal sites, aquaculture water use, and small "industrial" facilities, mostly related to agriculture have impacted the water quality of Jordan River and create an additional stress on the ecosystem.

3.2 Energy

Based on the energy mapping undertaken, energy supply appears to meet current demand in the JV. However, future energy demand is expected to increase a lot, necessitating the rapid development of an integrated strategy, based on renewable energy, for the JV.

3.3 Food security

Soil degradation – The agricultural land has been degraded due to continuous cultivation for millennia, resulting in an extremely low soil organic carbon. The impact of this situation is depicted in the estimated production yields for the JV. This is a common problem for the three jurisdictions (Israel, Jordan and Palestine) necessitating measures for soil restoration using agro-ecological practices and active carbon additions to soils that will improve soil quality, fertility and health.

3.4 Ecosystem

The environmental pressures exerted in the JV result from intensive agricultural activities (agriculture, livestock and aquaculture), tourism, climate change, geogenic pollution, growing population and invasive species. These pressures have resulted in significant impacts to the WEFE Nexus, such as surface water flow decline, groundwater depletion, high groundwater salinity, pollution and biodiversity loss. Integrated and sustainable management approaches are essential to mitigate these impacts and ensure the long-term sustainability of the region's ecosystems.

In addition to these four WEFE elements, other issues were identified as problematic and important to address. The impact of **climate change** was identified as an important issue in the JV, since precipitation in the North Ghor station was reduced from 395 mm in 1982 to 351 mm in 2021 (11% reduction) and in Mid Ghor from 338 mm in 1982 to 224 mm in 2021 (34% reduction), while the average temperature has increased by 1.9^{o}C in both stations during the same period (EcoFuture Deliverable 1.1).

The objective of EcoFuture's Task 1.2 was the development of the Causal Loop Diagram (CLD) for the JV (Deliverable 1.2), in all three jurisdictions, to help compare and contrast priorities. The CLD identified the WEFE Nexus challenges faced in the area and the key leverage point/actions that one can take to affect them as well as their interconnections and the interdependence between the challenges and the actions. Mapping of the WEFE system in the three JV jurisdictions can help identify the differences in stakeholders' key priorities, similarities and potential conflict points.

Water demand for irrigation & Water quality, **Renewable energy** availability, **Agricultural development**, and addressing **Biodiversity loss**, **Climate change and Population growth** were the elements on the initial list of identified challenges in the area, according to scientific experts. The Jordanian partners and stakeholders added two more challenges in the initial list of challenges: **soil quality** and **governance**, while Israeli's added **competition between development and land conservation and sanitation services** (wastewater & solid waste).

Governance needs to be done carefully when planning and implementing an NbS, and Criterion 5 of the Global Standard for NbS focuses specifically on the need for an inclusive, transparent and empowering governance processes for NbS (see Part 6 in this document). In addition, "population growth" is considered a driver, and not a challenge that NbS cannot help address. Therefore, both "governance" and "population growth" were removed from the list of relevant challenges to address, since NbS are not associated with them.

The Israeli, Jordanian and Palestinian stakeholders have similarities and differences in priorities for the three jurisdictions. Palestinian and Jordanian stakeholders have similarly prioritized challenges, while Israeli stakeholders have different priorities.

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

4. Presentation of relevant NbS for addressing challenges in the Jordan Valley from ThinkNature and Lenses

Within the context of the project "LENSES—LEarning and action alliances for NexuS EnvironmentS", funded by the European Union under the "PRIMA Foundation" program, a WEF (Water-Ecosystem-Food) Nexus framework was developed by the team of the Technical University of Crete. This framework was modified into a user-friendly module (nbscatalogue.lenses-prima.eu) to allow the selection of NbS. The conceptual design of the WEF Nexus-appropriate framework, for the assessment of resilience enhancement options, was built upon and adapted to the NbS classification scheme developed within the H2020 Thinknature project (Somarakis et al., 2019) and other available methodologies (Dimitru et al., 2021). The NbS classification scheme was a result of a synthesis conducted from a literature review and stakeholder consultation/discussion on the ThinkNature platform. The NbS tool includes a list of NbS along with additional information (type, ecosystem services, challenges, and SDGs) explained in specific factsheets that users can explore (Vanino et al., 2024).

To help practitioners navigate the landscape of NbS selection and assessment, a roadmap was developed within the framework of LENSES project, and the NbS practitioner must follow a step-by-step approach. The phases of this approach were described in detail in Vanino et al. (2024). Some important steps of this approach are to develop a vision for the landscape and identify the challenges relevant to the area. When implementing the WEF Nexus Evaluation Framework, it is possible to identify the services that the ecosystem would provide, and plan for increasing the provision of ecosystem services.

Finally, for each selected NbS, relevant Key Performance Indicators (KPIs) should be identified to assess their technical effectiveness. These KPIs will measure the enhancement of ecosystem services under specific conditions, the climate resilience of the solution, and its contribution to adaptation. The selections made should be consistent with the vision built in the previous phases. A stakeholder consultation is appropriate to be conducted on the selected WEF-optimized NbS, to revise and finalize the NbS list in the area (Vanino et al., 2024).

The aforementioned methodologies developed in LENSES and Thinknature projects were also used in the EcoFuture project, to identify the potential NbS relevant to the JV. Table 2 is based on Vanino et al. 2024 and presents a list of potentially relevant NbS (and some detailed type interventions to be implemented) for the JV, linked to the relevant challenges identified for the area, resulting from the CLD analysis.

Table 2: WEFE related NbS possible applicable in JV.

Type 1 – Actions to protect ecosystems / Better use of protected/natural ecosystems
Protection and conservation actions and strategies
• Limit or prevent specific uses and practices
• Ensure continuity with ecological network
• Protect forests from clearing and degradation
• Maintain and enhance natural wetlands

• Natural Protected Area network structure
Promotion strategy to reduce irrigation
Monitoring
• Assessment of NbS benefits
• Ecosystem services valuation methods
• Bio-indicators
Type 2 – Actions to sustainably manage ecosystems / NbS for sustainability and multifunctionality of managed ecosystems
Agricultural landscape management
• Agro-ecological practices
• Use grazing management and animal impact as farm and ecosystem development tools
• Change crop rotations
• Soil improvement and conservation measures
• Increase soil water holding capacity and infiltration rates
• Agro-ecological network structure
•Mulching
• Incorporating manure, compost, biosolids, or incorporating crop residues to enhance carbon storage
• Integrate biochar into agricultural soils
• Enrichment planting in degraded and regenerating forests
• Forest patches
• Hedge and planted fence
• Use soil conservation measures - cover crops
• Use soil conservation measures - Wind breaks
• Use soil conservation measures - minimum or conservation tillage
• Agroforestry
Type 3 – Actions to restore ecosystems / Design and management of new ecosystems
Ecological restoration of degraded terrestrial ecosystems
• Phytoremediation
• Systems for erosion control
• Soil and slope revegetation
• Plant trees/ hedges/perennial grass strips to intercept surface run-off
Restoration and creation of semi-natural water bodies and hydrographic networks
• Restore wetlands in areas of groundwater recharge
• Reconnect rivers with floodplains to enhance natural water storage
• Re-vegetation of riverbanks
• Re-meander rivers (where they have been artificially straightened) to help reduce speed and height of flood peaks

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

• Restore grassland/low input arable in drinking water catchments
• Target ponds/wetland creation to trap sediment/pollution runoff in farmed landscape
• Constructed wetlands and built structures for water management
• Rivers or streams, including remeandering, re-opening Blue corridors
• Floodplain restoration and management
Wastewater treated effluent improvement
• Wastewater treatment effluent with biofilm based technologies
• Rain harvesting for greenhouse irrigation to reduce soil salinization
• Use engineered reedbeds/wetlands for tertiary treatment of effluent

The proposed interventions were categorized into 3 broad types – 1) actions to protect ecosystems / for better use of protected/natural ecosystems; 2) actions to sustainably manage ecosystems / NbS for sustainability and multifunctionality of managed ecosystems; and 3) actions to restore ecosystems / design and management of new ecosystems. The NbS bundles are highlighted in light green in the table, and the respective interventions to be implemented as part of each bundle are highlighted in blue (based on Somarakis et al., 2019).

Table 3 presents the link between the NbS bundles and the challenges relevant to the JV. Three of the challenges identified as relevant in the JV (population growth, renewable energy availability and competition between development and land conservation) are not affected by NbS.

Table 3: Challenges potentially addressed by NbS bundles

	Climate change	Biodiversity	Agricultural development	Water demand for irrigation	Water quality	Governance	Soil quality	Sanitation services (wastewater and solid waste)
Protection and conservation strategies in terrestrial ecosystems	x	X			x	x	x	
Promote reduced irrigation practices	x	x	x	x	x	x	x	
Monitoring	x	x	x	x	x	x	x	x
Agricultural landscape management	x	x	x	x			x	
Ecological restoration of degraded terrestrial ecosystems	x	x			x		x	
Restoration and creation of semi-natural water bodies and hydrographic networks	x	x			x		x	
Wastewater treated effluent improvement	x	x	x	x	x		x	x

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

5. Presentation of relevant NbS for addressing challenges in the Jordan Valley

While reviewing the articles and collecting the data, we categorized NbS interventions into various types (e.g. ecological restoration, agroecological practices. *See full list below*). To analyse their relevancy to WEFE, we aligned these NbS type interventions with different the relevant water, energy or food sector, and/or ecosystems. Each NbS type was further contextualised, based on climate regions (Mediterranean, arid, semi-arid) and ecosystem types (e.g. dryland, grassland. *See full list below*). Last, we linked these solutions to the societal challenges they addressed (e.g. water and food security, disaster risk reduction. *See full list below*). Table 4 presents the results of the literature review.

Full list of categories and abbreviations used in Table 4:

NbS types:

ER - Ecological restoration (ecosystem / forest restoration)
EE - Ecological engineering
BI - Blue infrastructure (urban water management, NbS for water treatment, etc)
GI - Green infrastructure (NbS in urban context – green roofs/walls, etc)
EbA - Ecosystem-based adaptation
EM - Ecosystem-based mitigation
EbDRR - Ecosystem-based disaster risk reduction (flood reduction, fire mitigation etc)
AP - Agroecological practices (sustainable agriculture and food production = regenerative farming, plant and soil improvement, etc)
OT - Other solution which is not NbS (grey infrastructure, biomimicry, etc)

WEFE sectors:

W – Water; **En** – Energy; **F** – Food; **Ec** – Ecosystem

Climate:

M – Mediterranean; **A** – Arid; **SA** - Semi-arid

Ecosystem types:

D – Dryland
G – Grassland
W - Wetland / saltmarsh
F - Freshwater (streams / rivers / lakes)
U – Urban
AG – Agroecosystems
AQ - Aquaculture / mariculture
OT - Other

Societal challenges:

WS - Ensuring water security (quality, quantity, accessibility)
FS - Ensuring food security (quality, quantity, accessibility)
E - Contributing to energy (bioenergy, renewable, other)

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

BI - Addressing ecosystem degradation / biodiversity loss
ES - Ensuring the provisioning of ecosystem services (provisioning, regulating or cultural)
DRR - Addressing disaster risk (fire, flooding, etc)
CC - Addressing climate change (through adaptation/mitigation)
HH - Ensuring human health
SED - Ensuring social and economic development

Table 4: Bibliography review outcome – summary of information gathered from all articles reviewed. Article with "" mean that they are not necessarily NbS interventions, but they can complement an NbS, to strengthen it.*

Paper	NbS Description	NbS type	Climate type	Ecosystem type	Societal challenges	Other WEFE sectors
Water						
Jódar, J. et al., 2022	**Artificial recharge by means of careo channels versus natural aquifer recharge in a semi-arid, high-mountain watershed (Sierra Nevada, Spain)**					
	Water channels, locally known as *acequias de careo*. Their main function is collecting snowmelt and runoff from rainfall from the headwaters of river basins and distributing it to irrigated areas and recharge aquifers.	EE, GI	M, SA	F	WS, BI, CC	Ec
Everard, M. et al., 2021	**Livelihood security enhancement though innovative water management in dryland India**					
	NbS for **water-harvesting** (mainly monsoon run-off) implemented on common grazing land, in low slope and saline conditions of Salt Lake region of Rajasthan, India. The solution name is "chauka", and it comprises interlocking networks of low bunds on three sides of a rectangle built from spoil won from pits inside the rectangle. Spillways at the upstream edges of the bunds allow the free flow of water into adjacent bunded rectangles and from field to field, increasing soil moisture and recharging shallow groundwater.	EE, BI, EbA, AP	A, SA	D, AG	WS, FS, ES, SED	F
Masiero, M. et al., 2024	**Riparian Forests as Nature-Based Solutions within the Mediterranean Context: A Biophysical and Economic Assessment for the Koiliaris River Watershed (Crete, Greece)**					
	The **restoration of the native riparian forest** along the Koiliaris River in Crete, Greece. This restoration effort focuses on **re-establishing Helleno-Balkanic riparian plane forests**, which include species such as willow, alder, and Mediterranean hackberry. The restored riparian forest is intended to cover a total area of 335,450 m^2 along the riverbanks, acting as a natural buffer against flood risks by improving water retention and reducing erosion.	ER, BI, EbDRR	M	F	WS, BI, ES, CC	Ec

Paper	NbS Description	NbS type	Climate type	Ecosystem type	Societal challenges	Other WEFE sectors
Bigurra-Alzati, CA. et al., 2021	**Water Conservation and Green Infrastructure Adaptations to Reduce Water Scarcity for Residential Areas with Semi-Arid Climate: Mineral de la Reforma, Mexico**					
	Rainwater Harvesting from dwellings' roofs and **Green Infrastructure for rain run-off** may serve as solutions for water scarcity. Water can be used for domestic uses using local tanks for each house, and for other uses a system of pipes may collect the run-off.	GI	SA	U	WS	
Yahya, F. et al., 2023	**Decentralized Wetland-Aquaponics Addressing Environmental Degradation and Food Security Challenges in Disadvantaged Rural Areas: A Nature-Based Solution Driven by Mediterranean Living Labs**					
	Integration of constructed wetlands and aquaponics systems in rural, disadvantaged areas. These decentralized systems work by recycling water and nutrients, using natural processes to purify water for fish farming and crop production. The project was developed through the Mediterranean Living Labs initiative.	GI, AP	M	W, F, AG	WS, FS, CC, SED	F, Ec
Estelrich, M. et al., 2021	**Feasibility of vertical ecosystem for sustainable water treatment and reuse in touristic resorts**					
	A decentralized, nature-based solution for hotel **greywater (GW) treatment and reuse** was implemented through the installation of a pilot plant known as the **Vertical Ecosystem** (vertECO). This constructed wetland system was designed to treat greywater from a large hotel where GW was separated at the source.	GI	M	W, U	WS	Ec
Eekhout, JPC. et al., 2020	**The impact of reservoir construction and changes in land use and climate on ecosystem services in a large Mediterranean catchment**					
	Reforestation in the headwater areas of the Mediterranean Segura River catchment. This reforestation is aimed at controlling soil erosion, improving water regulation, and reducing sediment yield, which helps in flood management. Using natural processes through vegetation to enhance ecosystem services such as water retention, soil stability, and flood control.	GI	M	F, U	ES	F, Ec
	Pathways for climate change adaptations in arid and semi-arid regions					

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

Paper	NbS Description	NbS type	Climate type	Ecosystem type	Societal challenges	Other WEFE sectors
Singh, PK. et al., 2021	The Nature-Based Solutions (NbS) proposed and implemented focus on integrated adaptation measures that enhance resilience in arid and semi-arid regions. These include **improved water management practices** such as rainwater harvesting, watershed management, and micro-irrigation, which aim to secure water resources in the face of climate variability. Also, **natural farming-assisted soil rejuvenation**, including conservation agriculture and sustainable agricultural practices, designed to restore soil fertility and boost agricultural productivity. Additionally, the NbS promote livelihood diversification through the introduction of climate-resilient crop varieties and the sustainable management of natural resources, ensuring food security and reducing vulnerability to climate impact	BI, EbA, AP	A, SA	D	WS, FS, BI, CC	F, Ec
Reyes-Paecke, S. et al., 2019	**Irrigation of green spaces and residential gardens in a Mediterranean metropolis: Gaps and opportunities for climate change adaptation**					
	Irrigation of green spaces and residential gardens in the Metropolitan Area of Santiag, Chile. Optimizing water consumption by **adjusting irrigation practices** to align with the actual vegetation water requirements, based on a hydrological model. This emphasizes using more efficient irrigation systems, reducing lawn cover, and promoting drought-resistant species to ensure that cities can maintain green spaces without overusing water resources	BI	M	U	CC	Ec
García-Herrero, L. et al., 2022	**Cost-benefit of green infrastructures for water management: A sustainability assessment of full-scale constructed wetlands in Northern and Southern Italy**					
	Constructed wetlands as a Nature-Based Solution (NbS) for sustainable water management. These constructed wetlands are designed to treat different types of wastewater, including agricultural drainage and stormwater runoff. In Sicily, **a vertical subsurface flow constructed wetland** is implemented to treat surface runoff collected from a retail store's parking area, while in Emilia Romagna, a surface flow constructed wetland is used to treat agricultural drainage water.	GI	M	W	WS, BI, CC	Ec
	Mediterranean Riparian Areas-Climate change implications and recommendations					

Paper	NbS Description	NbS type	Climate type	Ecosystem type	Societal challenges	Other WEFE sectors
Zaimes, GN., 2020	**Restoration and protection of riparian areas**. These areas – behave as **ecotones between terrestrial and aquatic ecosystems**, provide essential ecosystem services such as flood control, water purification, groundwater recharge, and biodiversity support. Due to climate change and human activities, these areas have been heavily degraded. The proposed NbS emphasizes restoring natural hydrologic and geomorphologic regimes through soil and water bioengineering.	ER, EE	M	W, F	WS, BI, ES, DRR, CC	Ec
de Oliveira, FL. et al., 2024	**Conceptualising nature-based solutions: addressing environmental challenges in the city of Amman, Jordan**					
	Integrating urban **green infrastructure** (UGI), such as **parks, green roofs, and rainwater harvesting systems**, in the city of Amman, Jordan. Improving microclimates through increased vegetation, reducing heat stress, and promoting water conservation through rainwater capture and reuse.	GI	M, SA	U	WS, CC	Ec
Malamis, S. et al., 2021	**Recovering Non-Conventional Water Sources in the Mediterranean: The HYDROUSA Project Experience**					
	Integration of grey with green infrastructure (anaerobic treatment by upflow anaerobic sludge blanket coupled to vertical flow constructed wetlands) to treat wastewater and produce reclaimed water that is safe to reuse and rich in nutrients to be valorised for plant growth. Energytreatment of sewage. Demonstration of **sludge treatment wetlands** coupled with composting to treat anaerobic sludge and produce high added value compost. Rainwater/stormwater harvesting, storage into the aquifer to produce service water and agricultural irrigation water. Development of an agroforestry system: HYDROUSA has developed a biodiverse agroforestry system, based on the output of the local community, which is fertigated/irrigated with reclaimed water obtained from the treatment of sewage. It consists of trees and shrubs as superfood providers, and several local varieties of vegetable crops and aromatic plants as added value products	BI, GI, AP	M	W, AG	WS, FS, BI, CC	Ec
	How future changes in irrigation water supply and demand affect water security in a Mediterranean catchment					

Paper	NbS Description	NbS type	Climate type	Ecosystem type	Societal challenges	Other WEFE sectors
Eekhout, JPC. et al., 2024	**Reduced Deficit Irrigation** (RDI) was applied to irrigated tree crops and horticulture to reduce water demand while maintaining productivity, offering a more efficient irrigation scheduling strategy that enhances resource use efficiency. In combination with this, **Reduced Tillage and Cover Crops** were employed in both rainfed and irrigated agriculture to increase soil organic matter, improve water retention, and reduce erosion, making the agricultural system more resilient to climate change impacts. Additionally, Vegetated Buffer Strips were implemented throughout the catchment to reduce sediment transport and flood intensity, thereby improving water quality and the health of the ecosystem.	EbA, EbDRR, AP	SA	D, F, AG	WS, ES, DRR, CC	Ec
	The urgency of building soils for Middle Eastern and North African countries: Economic, environmental, and health solutions					
Deeb, M. et al., 2024	Design and use of constructed soils for dry climate requires the application of basic knowledge of soil pedogenic processes and biotic/abiotic interactions. **Constructed soils can contain artifacts including waste materials and semi-natural materials**. Soil construction for a wide range of restoration plans requires diagnosis and identification of degree of degradation, topography, and climate conditions, search for locally available waste and evaluating its agronomic and hydric characteristics, creating new soil layers and identifying their depth and function. Selecting the right plants for constructed soils, preferably native plants, with 671 key species accounting for 30% in success variation in constructed soil. Constructed soils are shown to enhance water storage, reduce the amount of water needed for irrigation, enhance food production, prevent erosion and salinization, promote microbial biodiversity, and increase plant production and survival, thereby delivering multiple ecosystem services.	AP	A, SA	AG	WS, FS, BI	F, Ec
	Optimizing Agroecological Measures for Climate-Resilient Olive Farming in the Mediterranean					

Paper	NbS Description	NbS type	Climate type	Ecosystem type	Societal challenges	Other WEFE sectors
Hrameche, O. et al., 2024	**Composting waste products** to enhance olive groves threatened by climate change and increased salinity. The use of other organic waste including straw, livestock waste, kitchen waste and sewage sludge will increase NPK availability and stocking of soil residual nutrients to prevent groundwater leaching. The technique can reduce artificial fertilizer input and improve carbon sequestration.	EbA, AP	M, SA	AG	FS, EN, BI, ES	En, F, Ec
Kakoulas, DA. et al., 2022	**The Effectiveness of Rainwater Harvesting Infrastructure in a Mediterranean Island**					
	Use of Rainwater Harvesting Systems (RWHs) are designed to capture rainwater from rooftops, which is then stored in tanks and used for non-potable applications like toilet flushing and irrigation. RWHs have been implemented in both residential settings and schools, with varying tank sizes and catchment areas assessed for their efficiency in saving water. By reducing reliance on the island's limited municipal water supply, these systems provide a practical, cost-effective approach to improving water security and promoting sustainable water management.	GI	M	U	WS, CC	Ec
Zhang, XY. et al., 2021	**Optimizing spatial layout of afforestation to realize the maximum benefit of water resources in arid regions: A case study of Alxa, China**					
	Optimizing afforestation which involves **planting Haloxylon ammodendron**, a drought-resistant tree species, to restore degraded lands and combat desertification.	ER	A	D, AG	WS, BI, CC	Ec
	Towards a sustainable viticulture: The combination of deficit irrigation strategies and agroecological practices in Mediterranean vineyards. A review and update					

Paper	NbS Description	NbS type	Climate type	Ecosystem type	Societal challenges	Other WEFE sectors
Romero, P. et al., 2022	**Design sustainable and climate-change-resilient agricultural systems** (e.g. vineyards) in Mediterranean semi-arid areas, based on agroecological principles - combining: 1. long-term sustainable water use (water saving strategies with low water volumes), 2. drought tolerant rootstock & scion, and 3. sustainable soil management practices (such as composting, mulching, cover, crops, and reduced tillage). This is to decrease irrigation needs, optimize irrigation, and improve water use efficiency in vineyards in semi-arid regions, thus great for CC adaptation and mitigation. The greatest and most-durable benefits will likely result from the combination of these adaptation measures with more-radical agroecological measures that will increase biodiversity and strengthen the resilience of farms and rural communities. These include the diversification of agroecosystems in the form of polycultures, agroforestry systems, and crop-livestock mixed systems, the use of hedgerows and water conservation and harvesting, and the general enhancement of agrobiodiversity, heterogeneity, and complexity.	AP	M	AG	WS, FS, ES, CC	F, Ec
Cristiano, E. et al., 2020	**Analysis of potential benefits on flood mitigation of a CAM green roof in Mediterranean urban areas**					
	Green roofs - a comparison of retention performance of two vegetation types.	GI, EbDRR	M	U	BI, DRR, CC	W
Liu, YF. et al., 2020	**Trade-off between surface runoff and soil erosion during the implementation of ecological restoration programs in semiarid regions: A meta-analysis**					
	By evaluating the effectiveness of different types of vegetation in regulating runoff and sediment transport in ecological restoration programs -> grassland may be the best choice for **optimizing the trade-off** between **catchment water yield** and **soil conservation** during the implementation of **ecological restoration** programs in semi-arid regions	ER, EbDRR	SA	D, U	BI, DRR	W
Food						
	Using fire to enhance rewilding when agricultural policies fail					

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

Paper	NbS Description	NbS type	Climate type	Ecosystem type	Societal challenges	Other WEFE sectors
Campos, JC. et al., 2021	High Nature Value farmlands (HNVf) is a long-term opportunity for fire suppression and biodiversity conservation. Traditional farming areas that support HNVf management would benefit the majority of species (more than 60%) to the detriment of rewilding scenarios. When agricultural policies fail, **rewilding reinforced by low fire suppression management** may provide an NbS. Based on Spanish case study: Rewilding benefits some species (20%), including critically endangered, vulnerable and endemic taxa, while several species (33%) also profit from open habitats created by fire.	EbDRR		OT	BI, DRR	Ec
Hart, TGB., 2011	**The significance of African vegetables in ensuring food security for South Africa's rural poor***					
	The paper examines the production of African vegetables in household food plots. It argues that **local production practices** (low-cost technologies) contribute more to food security requirements than extension services - inappropriate technologies that ignore these crops and local cultivation constraints.	AP	SA	AG	FS, HH	
Cortegano, M. et al., 2021	**'Mertola, a lab for the future' as a transformational plan for the mediterranean semi-arid region: A learning case based on landsenses ecology**					
	The solution was mainly a **community-based process**, which is multi-dimensional: **innovation, education, adoption of better agroecological and regenerative practices**	AP	SA	AG	FS, BI, ES, CC, SED	Ec
Hong, Z. et al., 2018	**Conservation Agriculture for Environmental Sustainability in A Semiarid Agroecological Zone under Climate Change Scenarios**					
	Conservation agriculture (CA) - (e.g. indigenous agricultural practices, agroforestry, terraces or ridges, minimum tillage cropping, cover cropping, large pits and intercropping) have the potential to improve soil fertility and mitigate climate change impacts	AP	SA	AG	CC, ES, BI	Ec
	Is the hillslope position relevant for runoff and soil loss activation under high rainfall conditions in vineyards?					

Paper	NbS Description	NbS type	Climate type	Ecosystem type	Societal challenges	Other WEFE sectors
Cerdà, A. et al., 2020	To address runoff and soil loss in vineyards, implement nature-based solutions that would **contribute to reducing soil erosion in agricultural land** by creating sink areas in the form of **hedgerows, ponds, or vegetation** strips where the surface wash deposits and water can sediment and infiltrate. In addition, other **management practices** contributing to reduction of erosion, such as **mulching** and **inter-row crops**. We state that there is an urgent need to apply strategies to reduce soil loss in vineyards.	ER, EbDRR	M, SA	D, OT, AG	BI, ES	F
Badiane, A. et al., 2001	**Use of compost and mineral fertilizers for millet production by farmers in the semiarid region of Senegal***					
	Based on this study, it is recommended to apply **combinations of manure/crop residue compost**, or **compost alone** on yields of millet in the semi-arid agroecological zone of Senegal.	AP	SA	D	FS	
Benayas, JMR. et al., 2017	**Potential of pest regulation by insectivorous birds in Mediterranean woody crops**					
	Pest regulation by **insectivorous birds can be enhanced during restoration of natural and semi-natural vegetation** in homogenous agricultural landscapes in temperate areas (e.g. planting forest islands and hedgerows). Farmers are encouraged to install nest boxes to reduce or eliminate pesticide use.	ER, AP	M	D	FS, ES, BI	Ec
	Biodiversity, climate change, and adaptation in the Mediterranean					

Paper	NbS Description	NbS type	Climate type	Ecosystem type	Societal challenges	Other WEFE sectors
Aurelle, D. et al., 2022	**Traditional crop breeding** - "Long-term adaptations rely on the selection and development of varieties by breeders and on significant changes in the management from the farm level to the regional scale that need increased knowledge and/or financial support." **Non-traditional water** - "Due to the non-sustainable overexploitation of groundwater for irrigation in many regions, the use of unconventional water sources is investigated. Reuse of wastewater is currently a much studied option that requires multidisciplinary analyses considering its low acceptation by farmers. **Desalination** is another option, despite its costs, but it needs revised treatment standards for providing irrigation water that is not ion depleted **Agroforestry** - is considered to be an interesting adaptation strategy in the Mediterranean basin as it enhances the capability of the agrosystem to better use limited water resources as well as nutrients NBS range from no or low intervention actions, such as establishing protected areas or ecological corridors, to more intrusive actions such as creating artificial ecosystems.	EE, EbA, AP	M	GR, W, F, U, AG	FS, BI, ES, CC	Ec
Bryan, E. et al., 2013	**Can agriculture support climate change adaptation, greenhouse gas mitigation and rural livelihoods? insights from Kenya**					
	The paper looks at **integrated soil fertility management**, **improved live-stock feeding**, **irrigation and soil and water conservation**. The results varied depending on the climate and soil content. It focuses on smallholder producers in Kenya and how they can integrate changes in their agricultural practices which provide a "triple win" - climate change adaptation, GHG mitigation and profitability.	AP	A, SA	D, GR, W, AG	FS, CC	Ec
Alba-Patiño, D. et al., 2021	**Social indicators of ecosystem restoration for enhancing human wellbeing**					
	Planting over 3000 almond trees of the Guara and Lauranne varieties to **restore desertified areas** with an **innovative tree-growing method to increase resilience**. These varieties are characterized by their late flowering, which makes them more resistant to frost. Their low water requirements, high resistance to drought, high productivity, and good fruit quality. Other auxiliary species such as rosemary and aromatic plants were planted around the almond trees to attract pollinators and diversify the crop	ER, AP	SA	AG	FS, SED, CC	

Paper	NbS Description	NbS type	Climate type	Ecosystem type	Societal challenges	Other WEFE sectors
Reckling, M. et al., 2023	**Diversification for sustainable and resilient agricultural landscape systems**					
	Diversification for providing sustainable solutions at different scales to improve both the agronomic and economic resilience of farming systems as well as the environmental resilience of landscapes. **Diversification** includes: **established and novel field arrangements** (e.g., diverse rotations, integration of legumes, cover crops, intercropping, patch cropping, pixel cropping, and agroforestry); (ii) **diversified farming systems** (e.g., mixed crop-livestock and mixed livestock farming, alternative social models like community supported agriculture and care farming; (iii) **diversified landscape systems** (e.g. rewetting of drained landscapes, and introduction of semi-natural habitats), and (iv) **diversified value chains**.	ER	A	AG	FS, ES	Ec
De Luca, Al. et al., 2023	**A methodological proposal of the Sustainolive international research project to drive Mediterranean olive ecosystems toward sustainability**					
	Cover crops, Livestock integration, Tree pruning and residues management, organic fertilization, No chemical treatments, Participation and knowledge exchange	AP	M	AG	FS, BI, ES, CC, SED	Ec
Ecosystem						
Chàfer, M. et al., 2020	**Greenery System for Cooling Down Outdoor Spaces: Results of an Experimental Study**					
	A shadow system consists of v**egetation growing on ropes**. Designed for cities to reduce temperature and increase humidity.	GI	M	U	CC, HH	
	Implementation of Nature-Based Solutions for Hydro-Meteorological Risk Reduction in Small Mediterranean Catchments: The Case of Portofino Natural Regional Park, Italy					

Paper	NbS Description	NbS type	Climate type	Ecosystem type	Societal challenges	Other WEFE sectors
Turconi, L. et al., 2020	The Nature-Based Solutions (NbS) proposed and implemented in the Portofino Natural Regional Park include the **stabilization of rock masses** and the **reduction of geo-hydrological risks** through the **restoration of terraces and the construction of dry stone walls**. These measures aim to intercept and reduce solid transport along rivers and decrease erosion, which helps protect the cultural and natural heritage of the area. Additionally, the project involves the **removal of non-native species** and the **promotion of natural regeneration of native vegetation**, to enhance the resilience of local ecosystems. These interventions are designed to address the specific challenges of the region, such as flash floods, landslides, and the impact of storm surges, while maintaining the landscape's aesthetic and cultural value	ER, BI, EbM, EbDRR	M	F	BI, ES, CC, SED	
Marando, F. et al., 2022	**Urban heat island mitigation by green infrastructure in European Functional Urban Areas**					
	the implementation of **Urban Green Infrastructure** (UGI) can partially reduce urban heat island (UHI) intensity, promoting a resilient urban environment and contributing to climate change adaptation and mitigation	EbA, EbM		U	CC	
Huang, QL. et al., 2024	**Predicting the geographical distribution and niche characteristics of Cotoneaster multiflorus based on future climate change**					
	It is crucial to select appropriate tree species and establish long term ecological restoration plans for drought-prone and semi-arid regions by utilizing species distribution data and environmental information to generate niche-based models that explore and predict species' response patterns to future climate change	ER	A, SA	D	BI, CC	
	Linking restoration outcomes with mechanism: the role of site preparation, fertilisation and revegetation timing relative to soil density and water content					

Paper	NbS Description	NbS type	Climate type	Ecosystem type	Societal challenges	Other WEFE sectors
Ruthrof, KX. et al., 2013	To link mechanistic drivers of seedling establishment with techniques to increase revegetation success, field-based experiments were undertaken in degraded periurban woodlands in Mediterranean southwestern Australia using two iconic tree species. Techniques such as site **preparation techniques (ripping)**, even in deep sandy soils, and **early planting,** reduce soil compaction and alter moisture availability within the soil profile, promoting deeper root growth and thus **increasing revegetation success** in degraded Mediterranean ecosystems	ER	M	D	BI	
	Coupling of different nature base solutions for pedestrian thermal comfort in a Mediterranean climate					
Arrar, HF. et al., 2024	.**Heat mitigation strategies** can help increase human wellbeing, **reduce heat stress in urban areas**, prevent heat-related health issues (including death) and improving the resilience of urban areas to extreme heat events. Practical guidance are offered here for stakeholders who renovate traditional cities in Mediterranean climates to make informed decisions about urban heat mitigation methods.	GI, EbA	M	U	BI, ES, CC, HH	
	Nature-based solutions for coastal risk management in the Mediterranean basin: A literature review					
Zanin, GM. et al., 2024	The key issues addressed, within the Mediterranean Region, are coastal erosion and flooding, both in present condition and under climate change. The NbS methods reviewed include **seagrass conservation, dune restoration, beach nourisment, sediment system restoration, wetland restoration, drainage, sea walls, dune construction**	EE	M	AQ	DRR, BI, ES	
	Nature-Based Solutions for Optimizing the Water-Ecosystem-Food Nexus in Mediterranean Countries					
Romero, P. et al., 2024	The study covers a number of pilot projects and their implemention, including **mulching, soil water management, agrecologicla practices, no-tillage agriculture, crop rotation, intercropping, microbial fertilization, regenerative practices**. The aims of these practices are to provide for water and soil conservation, improve yield, increase water and plant productivity. User barriers and perceptions are also explored	EE, EbA, EbM, AP	M, SA	W, F, AG	WS, FS, EN, BI, ES, DRR, CC	
	Mapping and evaluating the impact of flood hazards on tourism in South African national parks					

Paper	NbS Description	NbS type	Climate type	Ecosystem type	Societal challenges	Other WEFE sectors
Dube, K. et al., 2023	The publication highlights the importance of **wetland restoration** as a critical component of flood risk management Additionally, the study emphasizes the role of **maintaining ecological systems like wetlands and catchments**, which are crucial for reducing the impact of floods: "Nature-based solutions are critical in flood management...this calls for national parks to assist in managing various catchment systems that feed into the parks". These NbS are proposed to improve the resilience of park infrastructure and ecosystems against increasing flood risks	ER, EbDRR	SA	W, F	BI, DRR, CC	
	Towards a Standard Framework to Identify Green Infrastructure Key Elements in Dense Mediterranean Cities					
Delgado-Capel, M. et al., 2020	The publication proposes a systematic framework for improve **urban green infrastructure** (UGI) in the cities of the Mediterranean Region, using Granada, Spain, as a case study. The framework classifies green spaces into categories such as core areas, nodes, links, and "other" areas, based on their size and capacity to provide key ecosystem services like **air filtration and microclimate regulation**. As the publication states, "This categorization aims to **optimize the functionality of existing green spaces** and identify new areas to increase green space availability and functionality for urban residents". The goal is to improve urban resilience and promote green equity by ensuring that these green spaces contribute effectively to climate adaptation and the well-being of city inhabitants.	GI, EbA	M	U, AG	BI, ES, CC	
	Restoration islands: a tool for efficiently restoring dryland ecosystems?					

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

Paper	NbS Description	NbS type	Climate type	Ecosystem type	Societal challenges	Other WEFE sectors
Hulvey, KB. et al., 2017	The NBS proposal is **restoration of specific areas where whole-landscape restoration is not possible**. **Restoration islands** can potentially increase restoration success if strategically situated in the areas with favorable biotic and abiotic conditions. islands can serve as self-sustaining areas where ecosystem functions and services are restored and maintained in patches across the landscape. By focusing efforts on a limited area, managers can concentrate restoration resources in locations with a high potential for success or a high restoration priority. **Island-based plantings have been used to increase forage production, enhance wildlife habitat size, enhance pollinator habitat, develop migration corridors, weed control, fire management, erosion mitigation and provide a seed source for long-term nucleation**.	ER, EbM, EbDRR	M, SA	D	BI, ES, DRR	
Steed, A. et al., 2018	**Response of arthropod communities to plant-community rehabilitation efforts after strip mining on the semi-arid west coast of South Africa**					
	Vegetation rehabilitation treatments: **replacement of topsoil, seeding, and translocation** of mature plants and **nursery cuttings** to reintroduce species that were missing in the soil seed bank or species that do not establish well from seeds.	ER	SA	OT	BI	
Jiang, C. et al., 2018	**Integrating ecosystem services into effectiveness assessment of ecological restoration program in northern China's arid areas: Insights from the Beijing-Tianjin Sandstorm Source Region**					
	Protecting natural forests through logging bans, preventing sandstorms through afforestation, and converting the farmlands into forests and grasslands. The specific measures in the **ecological rehabilitation programs** involve natural enclosure of **grassland, reforestation, and afforestation** through **aerial seeding** or **closing hills**, and **conversion** of the **cropland to forest or grassland**.	ER, EE, EbDRR	SA	GR, F, U, OT	BI, ES	
Rosas-Ramos, N. et al., 2019	**The complementarity between ecological infrastructure types benefits natural enemies and pollinators in a Mediterranean vineyard agroecosystem**					
	Woodland hedges, rosaceous hedges, grass strips, and flower strips - their influence on the abundance and diversity of beneficial arthropods, such as predators, parasitoids, and pollinators in Mediterranean vineyards agroecosystem.	EE	M	AG	BI, ES	

Paper	NbS Description	NbS type	Climate type	Ecosystem type	Societal challenges	Other WEFE sectors
Saaroni, H. et al., 2018	**Urban Green Infrastructure as a tool for urban heat mitigation: Survey of research methodologies and findings across different climatic regions**					
	Urban Green Infrastructure as a tool for urban heat mitigation: Parks (including gardens), street trees, urban forests, and green coverage of buildings (roofs and/or walls)	ER, GI	M, A, SA	U	CC, HH	
Stephens, SL. et al., 2010	**Operational approaches to managing forests of the future in Mediterranean regions within a context of changing climates**					
	Adaptive strategies for forests in the Mediterranean, under future climate changes conditions, include **resistance options** (forestall impacts and protect highly valued resources), **resilience options** (improve the capacity of ecosystems to return to desired conditions after disturbance), **response options** (facilitate transition of ecosystems from current to new conditions), and **realignment options** (modifying forests to present and/or future conditions and restoring key ecosystem processes).	ER	M	OT	CC, ES, BI	
Cuthbert, MO. et al., 2022	**Global climate-driven trade-offs between the water retention and cooling benefits of urban greening**					
	"**Urban greening**" can be implementedas **green roofs**, **green walls**, or **vegetated urban spaces**. But cCommon urban greening strategies cannot yield high performance simultaneously for addressing both urban heat-island and urban flooding in most cities in the world.	GI, EbDRR	M, A, SA	U	ES, DRR, CC, HH	
Delgado-Capel, MJ. et al., 2023	**Capacity of Urban Green Infrastructure Spaces to Ameliorate Heat Wave Impacts in Mediterranean Compact Cities: Case Study of Granada (South-Eastern Spain)**					
	Urban Green Infrastructure (UGI) to mitigate the impacts of heat waves in Mediterranean compact cities. The UGI includes **parks, green spaces, small vegetated areas, and green roofs**	GI, EbA	M	U	CC, HH	
	Ecological restoration across the Mediterranean Basin as viewed by practitioners					

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

Paper	NbS Description	NbS type	Climate type	Ecosystem type	Societal challenges	Other WEFE sectors
Nunes, A. et al., 2016	The main **restoration** activity monitored across the case study was undertaken through the **introduction of plant species**. - This occurred through **Revegetation** with: **nursery-grown seedlings, seeding** (with local transplantations, regardless of the degradation cause). - **Hydroseeding** was exclusively in **restoration actions** following **industrial activities** (e.g. mining) or infrastructure development, in some cases associated with deforestation and drought. - The **introduction** (inoculation) of biological soil crusts, associated with degradation driven by infrastructure development (and consequent deforestation), **overgrazing or intensive agriculture**. Last, grazing exclusion was used as a restoration strategy in some of the projects. The **use of native species** and of local propagules in restoration plans should be promoted among restoration practitioners (e.g. technicians, local people) on the **importance of such species for local adaptation** to climate and other disturbances, particularly in a context of a changing environment, as well as to promote biotic interactions and ecosystem sustainability and resilience.	ER, AP	M, SA	D, GR	BI, DRR	
Wai, CY. et al., 2022	**A Systematic Review on the Existing Research, Practices, and Prospects Regarding Urban Green Infrastructure for Thermal Comfort in a High-Density Urban Context**					
	Urban green infrastructure: - **green roofs** (extensive/(semi) **intensive green roof**, blue roof), **vertical greenery system** (green/double skin green walls, green facades), **urban agriculture**, **rooftop greenhouse** - EnergyPlus is the most popular software used to conduct energy analysis for buildings, whereas ENVI-met is more commonly used for microclimate analysis.	GI	M	U	CC	
Wang, G. et al., 2022	**Regulated Ecosystem Services Trade-Offs: Synergy Research and Driver Identification in the Vegetation Restoration Area of the Middle Stream of the Yellow River**					
	Vegetation restoration: China's farmland to forest project (GFGP) to **restore cultivated land on steep hillsides to forest land or grassland**, and **restore barren mountains** and **wasteland** suitable for tree growth, so as to alleviate and prevent flood and soil erosion.	ER, EbDRR	A, SA	GR, W, F, AG, OT	BI, ES	
	Restoration research actions to address rapid change in drylands: insights from the Colorado Plateau					

Paper	NbS Description	NbS type	Climate type	Ecosystem type	Societal challenges	Other WEFE sector s
Young, KE. et al., 2023	Using **Indigenous knowledge**, along with **scientific knowledge** and modern society (and state) apparatus, to find the way to restoration.	ER	A, SA	D	BI, ES, CC	

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

6. Data analysis: Heatmaps

The following tables (Tables 5, 6 and 7) illustrate the correlation between the type of NbS and three variables: climate, WEFE sector, and ecosystem type. In some cases, the sample size is insufficient to draw statistically significant conclusions. However, there are several reliable results. The tables are displayed as heatmaps, with lower values shaded in green, higher values in red, and a gradient of colors representing the values in between.

We preselected articles that were only relevant to the three climate regions present in the JV (Mediterranean, Arid and Semi-Arid). In chi-square tests that we ran, there was no significant dependence between the two variables - NbS types and climate regions, NbS types and WEFE sectors, NbS types and ecosystem types - of tables 5, 6 and 7 respectively.

6.1 NbS types vs. climate regions

In Table 5, we can observe that when focusing on agroecological practices, there appears to be stronger relevancy of such solutions in arid and semi-arid climate regions, compared to the Mediterranean climate region. In addition, Green Infrastructure is more frequent in Mediterranean climate region than other climate regions.

*Table 5: Correlation between NbS and climatic regions (R*ed represents high number of occurrences between NbS type and climate regions, and green – low number of occurrences)

		Climate		
		Mediterranean	Arid	Semi-arid
NbS type	Ecological restoration (ecosystem / forest restoration)	7	6	6
	Ecological engineering	5	3	3
	Blue infrastructure (urban water management, NbS for water treatment, etc)	4	2	2
	Green infrastructure (NbS in urban context – green roofs/walls, etc)	12	3	3
	Ecosystem-based adaptation	5	5	5
	Ecosystem-based mitigation	3	2	2
	Ecosystem-based disaster risk reduction (flood reduction, fire mitigation etc)	5	5	5
	Agroecological practices (sustainable agriculture and food production = regenerative farming, plant and soil improvement, etc)	6	12	12

6.2 NbS type vs. WEFE sectors/category

In Table 6, it is notable and statistically significant, that almost no NbS pertain to the energy sector.

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

Table 6: Correlation between NbS and WEFE sectors (red represents high number of occurrences between NbS types and WEFE sectors/category, and green – low number of occurrences)

		WEFE sector/category			
		Water	Energy	Food	Ecosystem
NbS type	Ecological restoration (ecosystem / forest restoration)	3	0	3	10
	Ecological engineering	3	0	2	5
	Blue infrastructure (urban water management, NbS for water treatment, etc)	5	0	2	5
	Green infrastructure (NbS in urban context – green roofs/walls, etc)	10	0	2	12
	Ecosystem-based adaptation	4	1	4	8
	Ecosystem-based mitigation	0	0	0	4
	Ecosystem-based disaster risk reduction (flood reduction, fire mitigation etc)	4	0	2	9
	Agroecological practices (sustainable agriculture and food production = regenerative farming, plant and soil improvement, etc)	7	1	13	12

6.3 NbS type vs. ecosystem types

In Table 7, we observe that agroecological practices are strongly linked to agroecosystems, and that green infrastructure is strongly linked to urban ecosystems. Both these links are expectable, since the solutions are designed and implemented very specifically in these ecosystems.

Table 7: Correlation between NbS type and ecosystem type (red represents high number of occurrences between the NbS and ecosystem types, and green – low number of occurrences)

		Ecosystem type						
		Dryland	Grassland	Wetland / saltmarsh	Freshwater (streams / rivers / lakes)	Urban	Agroeco systems	Aquaculture / mariculture
NbS type	Ecological restoration (ecosystem / forest restoration)	6	0	2	4	1	2	0
	Ecological engineering	1	1	3	4	1	3	1
	Blue infrastructure (urban water management, NbS for water treatment, etc)	2	0	1	2	1	2	0
	Green infrastructure (NbS in urban context – green roofs/walls, etc)	0	0	4	3	9	3	0

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

	Ecosystem-based adaptation	3	1	2	3	4	6	0
	Ecosystem-based mitigation	1	0	1	2	1	1	0
	Ecosystem-based disaster risk reduction (flood reduction, fire mitigation etc)	4	0	1	4	2	2	0
	Agroecological practices (sustainable agriculture and food production = regenerative farming, plant and soil improvement, etc)	6	2	5	4	1	13	0

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

7. Presentation of NbS implemented in / relevant to the pilots

7.1 Jordanian pilot

The Jordanian part of JV suffers from serious agricultural issues influenced by water scarcity, water quality, changing environmental and climatic scenarios, and socio-economic factors impacting the agricultural community. Current agricultural practices also contribute to declining yields such as the annual reuse of the same agricultural land under greenhouses, which depletes the soil of critical nutrients. Thus, it is facing escalating agricultural problems influenced by shifting climatic conditions, and socio-economic dynamics that shape its farming community.

Based on the outcomes of the prioritization of challenges done by the stakeholders, where water quality and quantity, soil quality and agricultural development were stated as the most important issues to tackle, a follow-up workshop conducted a Community Capacity Assessment that assessed the capacity of the stakeholders to address their highest priority challenges by identifying the problems and barriers to fulfil the priorities. Participants had diverse educational backgrounds, with limited agricultural specialization. Over the years, they received training primarily focused on basic aspects of water quality and irrigation, with a lack of comprehensive understanding in soil quality and cooperative functions. Improvement is needed in specialized training and awareness of agricultural cooperatives. There was a reactive approach to maintenance and limited use of advanced technologies. While basic irrigation technologies were accessible, the use of laboratory analyses for water quality was rare. Participants had limited knowledge of regulations and standards for water and soil management. Key institutions were recognized, but there was a lack of understanding regarding the legal framework governing agricultural cooperatives. Increasing awareness and knowledge of relevant laws and regulations is crucial. Financial constraints were a significant barrier to adopting new technologies and improving agricultural practices. Costs for water and energy were burdensome, with participants generally dissatisfied with financial returns. Reliance on grid electricity was predominant, with minimal use of renewable energy sources. Energy costs impacted income, highlighting the need for affordable and sustainable energy options.

the Jordan pilot (Figure 1) was co-designed together with stakeholders, considering the main findings of the two workshops, and the activities to be carried out at the Pilot site can be summarized as follows:

1. Use of efficient irrigation system and irrigation based on soil moisture measurement.
2. Use of improved irrigation water quality with harvested rainwater from the two existing multi-spans for direct irrigation, rainwater harvested from the 6 plastic houses to be pumped to another existing irrigation pond, and desalinated water for irrigation using existing desalination unit very close to the selected pilot site area.
3. Use of Compost (80%) and Manure (20%) to improve soil quality on the plastic houses (4 plastic houses) with improved irrigation water quality and efficient irrigation management and efficient irrigation system.

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

4. Use of Floating PV panels installed over the irrigation pond to provide enough power to all used equipment including the desalination plant and at the same time decrease evaporation water losses from the pond as well as decrease algae growth at the water surface inside the irrigation pond.
5. Addition of fertilizers according to requirement – available in soil and automatically injected with the irrigation water while controlling both the EC and pH of the injected fertilizer solution.
6. Monitoring soil salinity and pH during and after the end of the season in all the 6 plastic houses.
7. Comparing the volume of irrigation water used and yield obtained from each plastic house.

The pilot site activities will bridge the identified WEFE challenges based on the following criteria:

- Improving the soil quality using the compost-manure mixture will improve the soil moisture holding capacity of the soil and together with using efficient irrigation system and managing irrigation through soil moisture measurements will reduce the amount of irrigation water used in the plastic house as well as improving the fertilizer use efficiency;
- Using an efficient fertilizer injector and having the amounts required considering the amounts available in the soil will improve the environment and reduce the amounts of chemicals added (improve environment);
- Use of pesticides effectively and efficiently as required to minimize their use (improve environment);
- Higher yield from the plastic house is expected from better irrigation management, better water quality, and better soil quality;
- Using harvested rainwater and desalinated water will lower soil salinity under plastic houses and improve soil productivity (better environment);
- Using solar energy (floating system) over the surface of an irrigation pond will save grid electric power and thus improve environment and provide an energy source. Additional benefits are decreasing water evaporation losses from the pond (an average depth of 6.7mm/day) as well as lower algae growth that will have a negative effect on the water filters and on the drip irrigation system. These are the existing problems for irrigation ponds in JV;
- Improved water quality through water harvesting and the use of desalination.

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

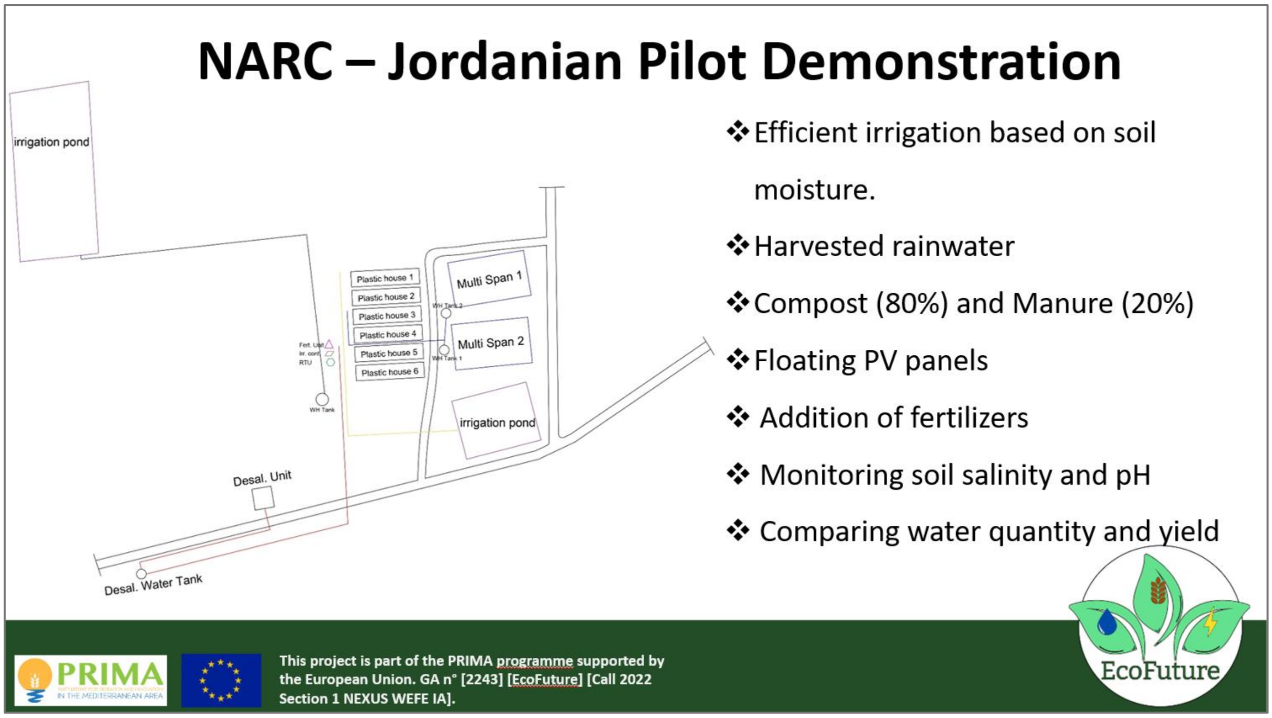


Figure 1: NARC pilot demonstration

As a result, we will use the following NbS bundles in the Jordanian pilot that contribute to more than one component of the WEFE Nexus and related challenges:

- Blue infrastructure: Wastewater treated effluent improvement, Monitoring, Promote reduced irrigation practices
- Green infrastructure: Rainwater harvesting, Dual use of reservoirs for water retention and energy production
- Ecosystem-based adaptation and Agroecological practices: Agricultural landscape management

These NbS will address the following:

- Improved nutrient cycling and soil fertility
- Improved water quality
- Increased access to green infrastructure
- Sustainable urbanization
- Creation of green jobs relating to the construction and maintenance of NBS
- Increased communities’ share of ownership
- Increased willingness, participation, investment in NbS
- Education, knowledge exchange and learning

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

7.2 Israeli pilot

The focus of the Israeli pilot is fishpond farming because the Valley of the Springs is economically dependent on aquaculture with 60% of Israel's fishpond farms located in the region. The main concerns raised by the Israeli living lab was about competition from imports, the high cost of inputs and government regulations, especially around the release of water from the ponds into the environment which serve as a barrier to efficient production. On the other hand, representatives of the Israel Nature and Parks Authority and local environmental units raised concerns about the eruption of the jackal populations due to the abundance of dead fish washing up on the shores of the fishponds. Paradoxically, environmentalists also raised concerns that the shrinking of the fishpond industry in the region reduces habitat for natural species if those abandoned fishponds are not rewilded and turned into building development instead. The Israeli Ministry of Agriculture has asked the fish farmers to develop a strategic plan for the future of aquaculture in Israel and therefore, the EcoFuture initiative can be seen as a welcome addition to the process. During the Israeli living lab, a disagreement arose among the farmers and experts as to the future direction of fish farming in Israel. Some advocated for regulations and technology which would improve the economic performance of conventional open fishponds, while others advocated for intensive fish farming called Recirculatory Aquaculture System (RAS). Finally, a proposal emerged to operate two pilot demonstrations, one in a traditional open fishpond setting and one using RAS.

Open Fishpond Pilot Demonstration (Figure 2): A large pond is used as a reservoir for regulating and treating water, while small satellite ponds are used to grow fish in a larger biomass to water ratio with more control over water quality and temperature, and less food waste. The large reserve pond can be covered by solar panels to provide electricity for the water pumps and will reduce water loss from evaporation. Previous attempts at covering fishponds with solar ponds have been less successful due to the bird population which feeds off the fish and leaves their droppings on the panels, rendering the panels ineffective in producing electricity. If the large ponds no longer contain fish, the bird population around the pond will be significantly reduced. The smaller ponds can be covered by nets to prevent attracting bird populations. The pilot is being implemented in an existing fishpond at the Nir David fish farm in the Valley of the Springs not far from Eden Farm Agricultural Research Station. A series of small ponds adjacent to and east of a large 135 dunam fishpond will serve as the open fishpond pilot demonstration. The open fishpond pilot includes sensors to monitor the oxygen levels in the reservoir and small ponds, and mechanism for collecting, storing, and analyzing data.

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

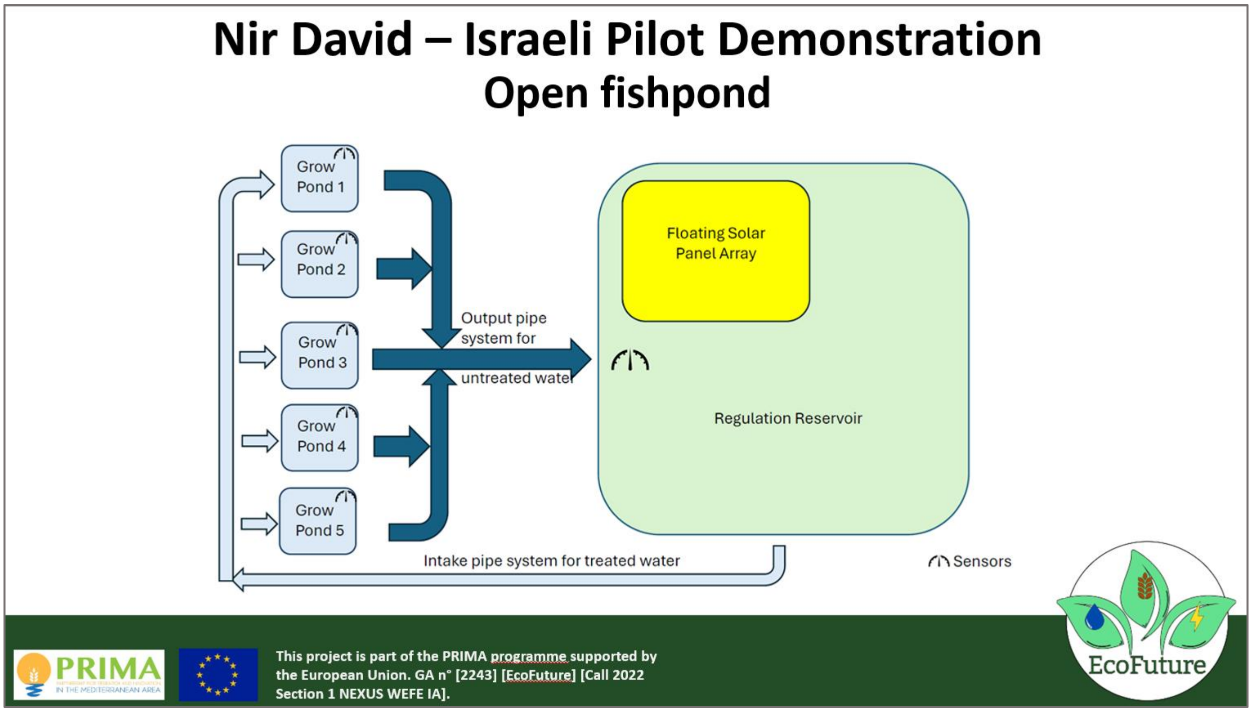


Figure 2: Nir David pilot demonstration

The pilot activities will address the WEFE as follows: With the decline in the economic viability of open fishpond farming, according to Israel's Ministry of Agriculture, the amount of dunams of fishponds in the Valley of the Springs has been in steady decline over the past few years. While fish farming had many negative externalities including ground water degradation and stimulation of the jackal population due to the ready availability of dead fish, the ponds also served as natural habitat for many species, having replaced the original wetlands which thrived in the region before human settlement. When the fish farms are abandoned due to economic infeasibility, they are not returned to their natural wetland status but converted to more profitable housing and commercial developments resulting biodiversity loss. If the open fishpond pilot is a success, the methodology demonstrated will raise profitability by increasing yield per input, enabling fish farming to continue to flourish and provide fresh fish to the Israeli market. Converting large fishponds into regulation reservoirs reduces the negative environmental externalities while preserving the status of the ponds as natural habitats for species in the area. The use of solar panels will provide clean energy to run the circulation pumps and will reduce evaporation in the ponds. The panels will be more effective since the reservoirs will attract less birds than they did as large fish growing ponds, so the panels will remain cleaner and more effective.

Recirculatory Aquaculture System (RAS) (Figure 3)**:** *Innovalley*, the Valley of the Springs, regional innovation center and the Eden Farm Agricultural Research Station are planning to develop an RAS facility to grow salmon. The high value of salmon on the Israeli fresh fish market is expected to justify the high costs of intensive fish farming. EcoFuture has joined *Innovalley* and the Eden Farm Research Station to establish a pilot RAS on the Eden Farm site. An existing structure has been equipped with breeding tanks, piping and insulation. EcoFutures has joined the *Innovalley* and Eden Farm's RAS initiative funding sensors and a heating and cooling exchange system. The structure was formally used as a quarantine site and is adjacent to a small reservoir which will be used to regulate the water and will also produce electricity for the pilot based on floating solar panels. The pilot itself is inside an enclosed building to regulate climate conditions and include fish tanks for growing fish at different stages of development.

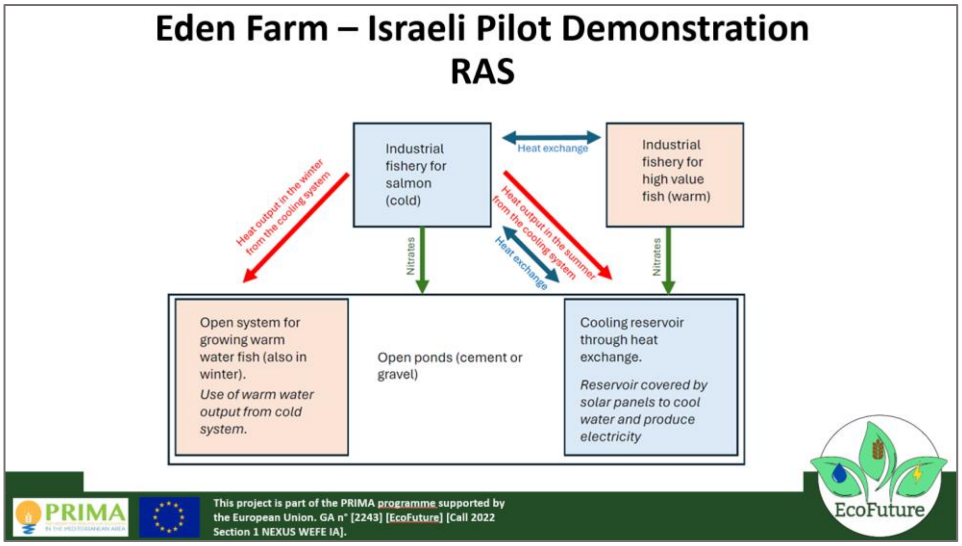


Figure 3: Eden farm pilot demonstration

If the pilot is successful a full-scale commercial model will be constructed at a nearby kibbutz and other high value fish can be introduced into the fish farming industry offering a new lease on life for an industry which is threatened by imports, high input costs, environmental pressures, and lack of interest on the part of the next generation in conventional fish farming.

The pilot activities will address the WEFE as follows: By enabling fish farmers to grow high value fish, such as salmon, sea bream and crabs, the RAS pilot can demonstrate improved profitability and attract a new generation of fish farmers in the Valley of the Springs while providing locally grown fresh fish to the Israeli market. The closed Recirculatory Aquaculture System (RAS) prevents nutrient laden wastewater produced by conventional fish farming from polluting the groundwater. Recirculation of the water will also reduce dramatically; water use in fish farming. As with the open fishpond pilot, a large open reservoir will be utilized as a regulating body of water absorbing and treating nutrients while continuing to serve as a natural habitat to some local species. Floating solar panels on the reservoir will reduce evaporation, cool down the water and provide enough clean electricity for the pumps, air conditioning and heat exchange systems.

As a result, we will use the following NbS bundles to the Israeli pilots that contribute to more than one component of the WEFE Nexus and related challenges:

- Restoration and creation of semi-natural water bodies and hydrographic networks
- Protection and conservation strategies in terrestrial ecosystems

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

- Wastewater treated effluent improvement
- Monitoring
- Dual use of reservoirs for water retention and energy production
- If the adoption of RAS in the area results in a smaller open fishpond ecological footprint, additional steps must be taken to rewild at least some of the closed fishponds to ensure that not all previous ponds which also served as natural habitats are not converted into housing developments.

7.3 Palestinian pilot

Marj Naje, a village of approximately 800 people, lacks a proper sanitary sewage system. Instead, residents are forced to rely on primitive methods for wastewater disposal, such as cesspits, increasing the risk of disease and groundwater contamination. In addition, the village is economically dependent on agricultural and due to Israeli control of water resources and the increased impact of climate change on precipitation in the region, water for agriculture is scarce. The current water supply comes from wells which are highly saline and can no longer support cash crops.
The Palestinian Living Lab agreed that the priority for the village is to solve the wastewater treatment problem and to provide additional water for agriculture. The constraints are that the groundwater is highly saline and must be desalinated to provide water for cash crops, electricity is expensive and unreliable, the village lacks a sewage grid and will not be able to get a permit to build a sewage line across route 90. A desalination unit was installed in 2014 for a local well, but the unit does not function.

Designing a sewage collection system in Marj Naje involves several key steps to ensure effectiveness, efficiency, and environmental sustainability. The pilot comprises several key components (Figure 4):

- A main sewer line;
- Secondary sewer lines from homes to the main sewer lines;
- Pumping stations - the topography of the village should allow most of the sewage to flow by gravitation but there may be some areas which require pumping;
- 15-20 CM/d wastewater treatment plant (WWTP);
- Desalination pump for local well;
- Storage tanks for mixed water;
- Solar panel array for operating the desalination pump;
- Treated wastewater pipelines to convey water to agricultural plots and adjacent greenhouses.

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

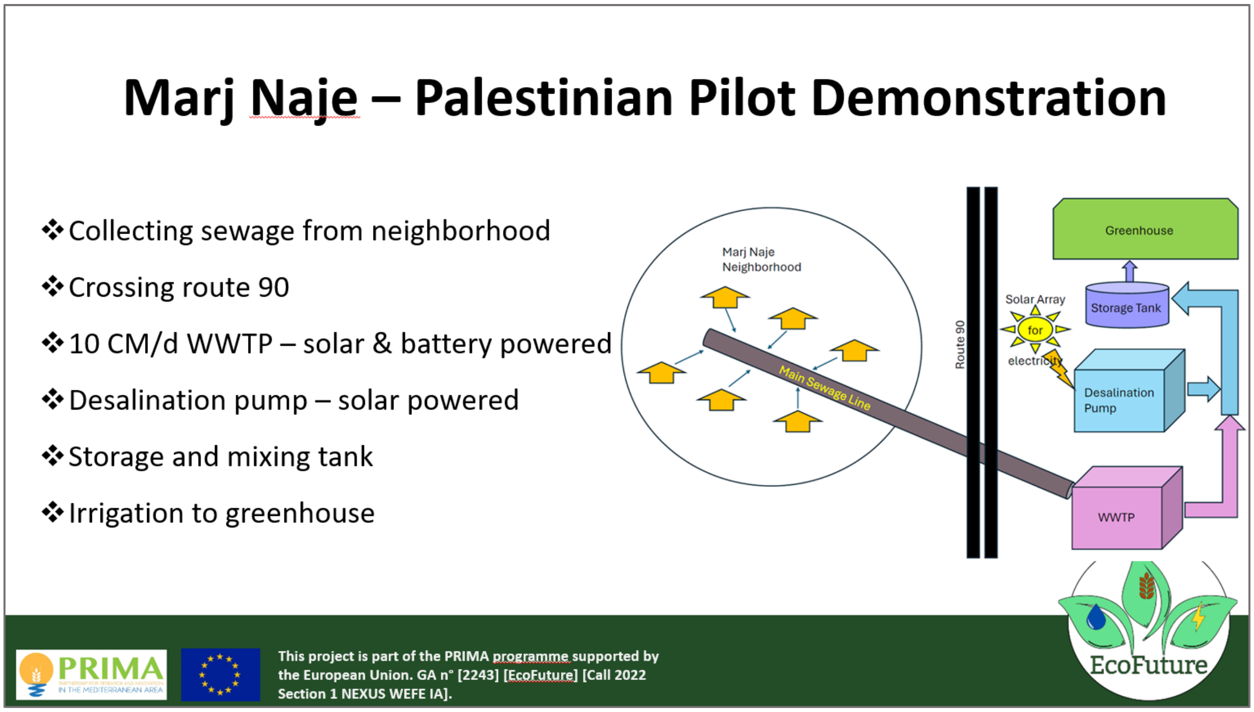


Figure 4: Marj Naje pilot demonstration

The focus of the pilot is to turn wastewater which is polluting the groundwater due to a lack of centralized sewage, into useful agricultural water. Desalinization of local groundwater mixed with the treated wastewater will increase the amount of water available for agriculture and enable farmers to produce cash crops in greenhouses, increasing local food supplies and strengthening the village economy. The power needed to run the WWTP, and the desalination pump will be supplied through clean solar energy. Preventing groundwater degradation, providing water for agriculture, and utilizing solar energy are good examples of a WEFE nexus.

As a result, we will use the following NbS bundles to the Palestinian pilot that contribute to more than one component of the WEFE Nexus and related challenges:

- Agricultural landscape management
- Wastewater treated effluent improvement
- Mixing desalinated water with treated effluent for agricultural use
- Monitoring
- Clean energy production

8. Global Standard for Nature-based Solutions

The NbS definition and their 8 related principles (Cohen-Shacham et al., 2019) were the basis for developing the Global Standard for NbS, which can be used by different stakeholders all around the globe, to design, implement, assess, adapt and improve NbS interventions (IUCN, 2020a). There are several components to the Global Standard – a general document (IUCN, 2020a), a detailed guidelines for its implementation (IUCN, 2020b), and a self-assessment tool that was recently made available for people to use online (https://nbs-sat.iucn.org/). The Global Standard for NbS has 8 criteria and 28 indicators (see IUCN, 2020a for the full list of indicators), which focus on and describe the most important relevant and important aspects to consider when planning and implementing NbS interventions:

- Criterion 1: NbS effectively address **societal challenges**
- Criterion 2: Design of NbS is informed by **scale**
- Criterion 3: NbS result in a net gain to **biodiversity and ecosystem integrity**
- Criterion 4: NbS are **economically feasible and viable**
- Criterion 5: NbS are based on **inclusive, transparent and empowering governance processes**
- Criterion 6: NbS equitably **balance trade-offs** between achievement of their primary goal(s) and the continued provision of multiple benefits
- Criterion 7: NbS are **managed adaptively**, based on evidence
- Criterion 8: NbS are **sustainable and mainstreamed** within an appropriate **jurisdictional context**

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

9. Next steps

9.1 Data management

One of the key factors for the success of this project is effective data management. The data collected has many variables, so it is suggested that it be managed in a database using consistent terminology agreed upon by all participants. Additionally, given that one of the project's outcomes is the development of an efficient data management system, it could also be used in future similar projects. This would add value to the project, beyond the primary objectives of proposing and implementing solutions to challenges in the JV.

For this purpose, we have been developing three structural tables (Tables 8, 9 and 10) that will help organise data and facilitate future data analyses. These tables will focus on the following:

- Stakeholders
- Challenges
- Solutions

Table 8: Structural table for data related to the stakeholders

Variable	Values
Personal dentification	Stakeholder's names and contact details
Jurisdiction	• Israel • Jordan • Palestine
Stakeholder type	• Decision/policy maker at national level • Decision/policy maker at the regional level • Decision/policy maker at local authority / municipality • NGO • Manager • Famer • Local community
WEFE Sector / category	• Water • Energy • Food • Ecosystem
Activities variables (participation in workshop, online survey)	• Participated • Not participated

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

Table 9: Structural table for data related to the challenges considered in the broader context (Some words are mentioned in italics to describe challenge more in detail).

Variable	Values
Challenge	• Climate change • Biodiversity *loss* • *Lack of enabling conditions for* agricultural development • *Increasing* water demand for irrigation • Water quality *degradation* • Soil quality *degradation* • *Lack of* Sanitation services (wastewater and solid waste)
Jurisdiction	• Israel • Jordan • Palestine
WEFE Sector	• Water • Energy • Food • Ecosystem
Societal Challenge (IUCN 2020a)	• Climate change • Biodiversity loss and ecosystem degradation • Ensuring Disaster risk reduction • Ensuring water security • Ensuring food security • Ensuring human health • Ensuring Economic and Social development
SDG – UN Sustainable Development Goals (United Nations 2015)	1. No poverty 2. Zero hunger 3. Good health and well-being 4. Quality education 5. Gender equality 6. Clean water and sanitation 7. Affordable and clean energy 8. Decent work and economic growth 9. Industry, Innovation, and Infrastructure 10. Reduced Inequality 11. Sustainable cities and communities 12. Responsible consumption and production 13. Climate action 14. Life below water 15. Life on land 16. Peace, justice, and strong institutions 17. Partnerships for the goals

**We may find it useful to have different variables for each jurisdiction, WEFE sector, societal challenge, and SDG, that will get the value of 0 or 1 for relevancy.*

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

Table 10: Structural table for data related to the solutions

Variable	Values
Solution	*List of suggested NbS (based on the list in paragraphs 3,4) and other suggested solutions*
Solution type	• Ecological restoration (ecosystem / forest restoration) • Ecological engineering • Blue infrastructure (urban water management, NbS for water treatment, etc) • Green infrastructure (NbS in urban context – green roofs/walls, etc) • Ecosystem-based adaptation • Ecosystem-based mitigation • Ecosystem-based disaster risk reduction (flood reduction, fire mitigation etc) • Agroecological practices (sustainable agriculture and food production = regenerative farming, plant and soil improvement, etc) • Other solution which is not NbS (grey infrastructure / biomimicry / …)
Ecosystem type	• Dryland • Grassland • Wetland / saltmarsh • Freshwater (streams / rivers / lakes) • Urban • Agroecosystems • Aquaculture / mariculture
Jurisdiction	• Israel • Jordan • Palestine
WEFE Sector	• Water • Energy • Food • Ecosystem
Challenge	• Climate change • Biodiversity *loss* • *Lack of enabling conditions for* agricultural development • *Increasing* water demand for irrigation • Water quality *degradation* • Soil quality *degradation* • *Lack of* Sanitation services (wastewater and solid waste)

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

Variable	Values
NbS Global Standard criteria	1. NbS effectively address societal challenges 2. Design of NbS is informed by scale 3. NbS result in a net gain to biodiversity and ecosystem integrity 4. NbS are economically feasible and viable 5. NbS are based on inclusive, transparent and empowering governance processes 6. NbS equitably balance trade-offs between achievement of their primary goal(s) and the continued provision of multiple benefits 7. NbS are managed adaptively, based on evidence 8. NbS are sustainable and mainstreamed within an appropriate jurisdictional context

**We may find it useful to have different variables for each ecosystem type, jurisdiction, WEFE sector, challenge, NbS global standard criterion, that will get the value of 0 or 1 for relevancy.*

9.2 Stakeholder engagement

Another key factor for the success of this project is the engagement and cooperation of the stakeholders. This issue is of great importance within the framework of EcoFuture and most of the deliverables are directly related to it. At this stage we have completed Phase A, which includes identifying and prioritising the challenges for each jurisdiction (Figure 5 from D1.2).

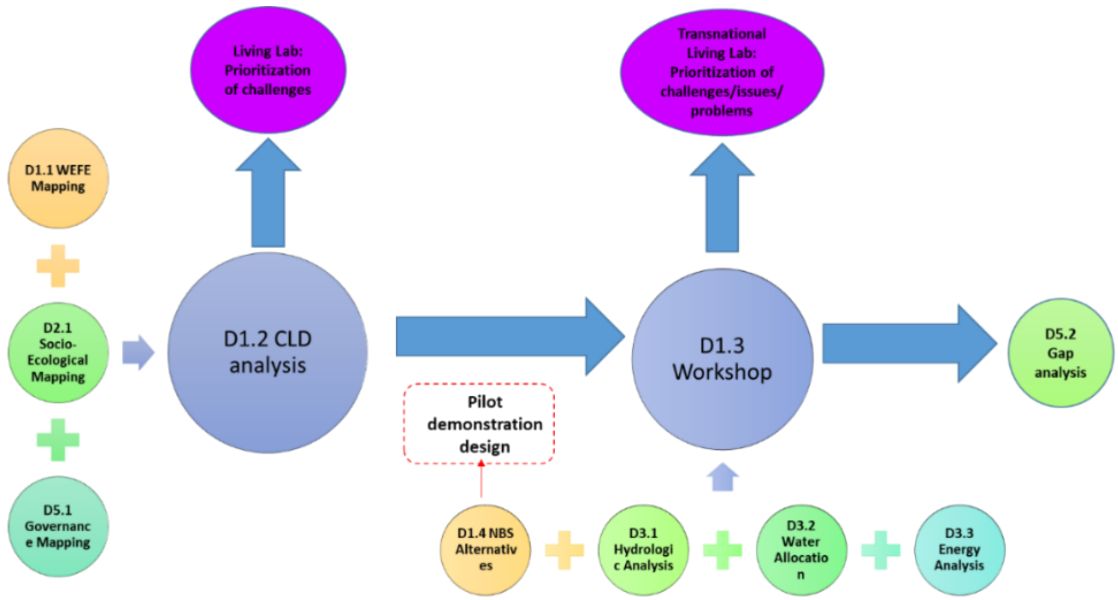


Figure 5: Phase A of stakeholder engagement within EcoFuture

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

The objective of Phase B of stakeholder engagement is to co-design with stakeholders the potential alternatives to address the challenges and issues faced by the JV. The results and feedback of the second phase of stakeholder engagement will be included in D2.3 and D2.4 (Figure 6 from D1.2).

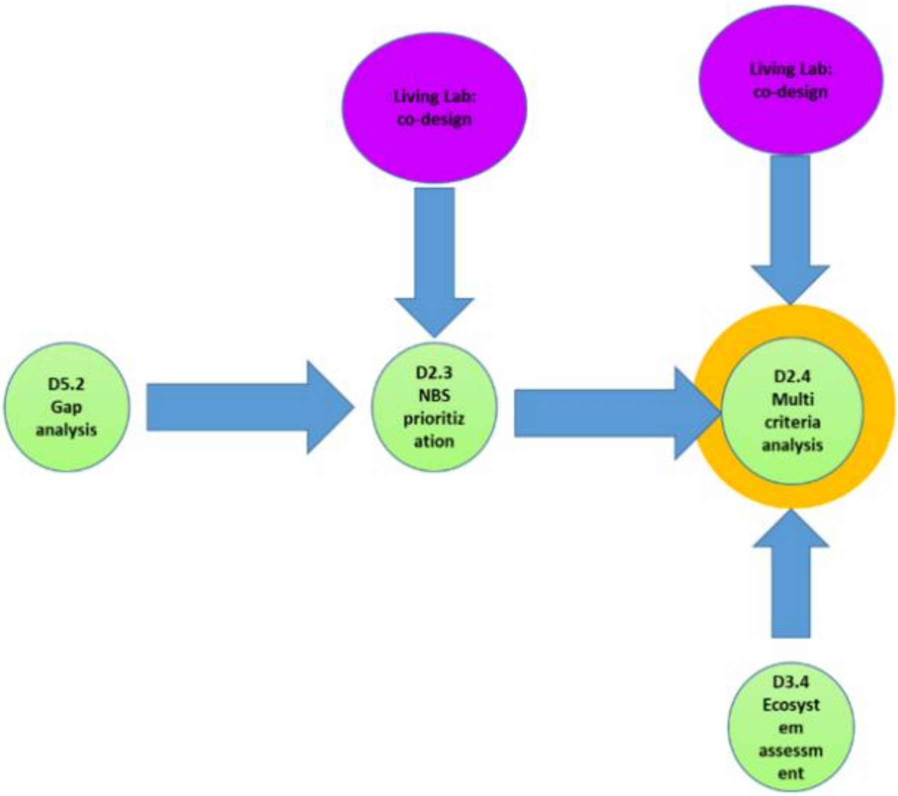


Figure 6: Phase B of stakeholder engagement within EcoFuture

The objective of D2.3 is to derive a stakeholder understanding and engagement to the suggested NbS bundles and to devise efficient management strategies to minimise the costs and externalities within a participatory framework. Evaluation of alternatives will integrate a wide range of (often conflicting) objectives and criteria of different nature in the presence of several groups of the stakeholders involved in the decision-making process (D2.4).

Phase C of stakeholder engagement will not be discussed here.

In order to engage with the stakeholders, a few steps will need to be taken:

a. Prepare the following:

- Compiling a list of stakeholders [based on D5.1].
- Creating an online questionnaire for the stakeholder to fill in.
- Preparing reading materials that outline the project details and the importance of stakeholder participation.
- Recording a YouTube or Zoom lecture that covers the content presented in the reading materials.

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

b. Initial email contact with each relevant stakeholder to include:

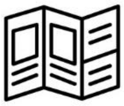
- A brief, personalised email will be sent to the stakeholder introduction for the stakeholder.
- An inquiry about whether they would prefer to contribute through an interview or through the questionnaire.
- Attached reading materials.
- A link to the recorded materials (lecture).
- A link to the online questionnaire.

c. Proceed with initial analysis aiming at:

- Evaluating the quality of responses.
- Identifying key stakeholders who have not responded.

In addition, there are a number of potential ways in which **NbS and the Global Standard for NbS** may be used in the next steps of the project, and be helpful for the local stakeholders:

a. Raise stakeholders' awareness on NbS:



- Produce informative brochure on NbS and the Global Standard for NbS.
- Organize stakeholders' workshop with training [T6.5] on NbS, on the potential NbS interventions relevant to the JV, and on Global Standard for NbS.

b. Support stakeholders in planning strong NbS:

- Stakeholders will learn about the information gathered on NbS relevant to the JV ecosystems and climate, and societal challenges to address.
- Stakeholders will be able to discuss and prioritize the most important societal challenges [T2.4] that they want to address in their own context, and plan NbS interventions and different scenario to address them.

- Stakeholders will be able to assess the best alternatives [T2.4], implementing the 8 criteria of the Global Standard for NbS.

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

10. Discussion

The extensive literature review undertaken aimed at exploring various NbS that address societal challenges such as climate change, water scarcity, and biodiversity loss. The common thread that we could observe among these solutions, looking into the link with the WEFE Nexus, is their strong focus on the Water and Food sectors, as well as on Ecosystem. Whether it is by improving water efficiency in agriculture, restoring degraded ecosystems, or building more resilient farming practices, these NbS create synergies across multiple sectors. They often aim to reduce water use, increase biodiversity, and enhance the resilience of natural systems, particularly in the face of climate change.

However, it has been harder to find NbS directly linked to the Energy sector. The reason for this might be that NbS are based on natural processes, which don't necessarily relate to traditional energy generation systems. While NbS can reduce energy demand – such as cutting the need for cooling through urban greening or minimizing irrigation energy use - they don't produce energy in the same way solar or wind technologies do. The Energy sector tends to rely more on technological solutions, making it more difficult to integrate natural processes into energy production. Therefore, NbS are more commonly associated with Water, Food, and Ecosystem, where ecological systems have a more direct role to play.

When looking more in details at the analyses that were undertaken with different stakeholders in the region, it was interesting to notice that for the selection of challenges (Part 2), different stakeholders understood and considered societal challenges differently. Also from an NbS perspective, when stakeholders were asked to look into the major societal challenges that NbS could address, they understood very different things. The outcomes of NbS should always be to influence positively society and the environment, therefore, some of the identified challenges by stakeholders weren't considered as relevant to NbS as NbS cannot address them. These include "population growth" and "governance". Population growth is usually considered a driver, rather than a challenge to address. Likewise, governance is something that needs to be done carefully when planning and implementing an NbS, and Criterion 5 of the Global Standard for NbS focuses specifically on the need for an inclusive, transparent and empowering governance processes for NbS (Part 6). Therefore, although they were selected by local stakeholders, both "governance" and "population growth" were removed from the list of relevant challenges to address, since NbS cannot address them.

Last, it is worth noting that Principle 2 of NbS (Cohen-Shacham et al., 2019) invites planning and implementation of NbS to be complemented by interventions or tools that may help to strengthen the NbS. Both the promotion of good practices and monitoring would be considered according to the IUCN framework as such complementary actions and tools, to strengthen NbS (Type 1 in Table 4).

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

References

- Boulad, N., Al Shogoor, S., Sahwan, W., Al-Ouran, N., & Schütt, B. (2021). Systematic conservation planning as a tool for the assessment of protected areas network in Jordan. *Land*, *11*(1), 56.
- Canals Ventín P., and L. Lázaro Marín, 2019. Towards Nature-based Solutions in the Mediterranean. IUCN Centre for Mediterranean Cooperation, Spain. https://iucn.org/sites/default/files/2022-07/towards_nature-based_solutions_in_the_mediterranean.pdf
- Cohen-Shacham, E, Andrade, A., Karangwa, C., Maginnis, S. 2024. Proposing the IUCN Global Standard for NbS as the main operational framework to implement UNEA Resolutions 5/5 on NbS for supporting Sustainable Development. IUCN, Gland.
- Cohen-Shacham E, Andrade A, Dalton J, Dudley N, Jones M, Kumar C, Maginnis S, Maynard S, Nelson C, Renaud F, Welling R, Walters G. 2019. Core principles for successfully implementing and upscaling Nature-based Solutions. Environmental Science and Policy 98: 20-29.
- Cohen-Shacham, E, Walters, G, Janzen, C and Maginnis, S (eds). 2016. Nature-based Solutions to address global societal challenges. Gland, Switzerland: IUCN. xiii + 97pp: https://portals.iucn.org/library/node/46191
- Dimitru, A.; Wendling, L. Evaluating the Impact of Nature-Based Solutions: A Handbook for Practitioners; European Commission: Brussels, Belgium, 2021.
- Hadadin, N., Al-Majali, Z., & Eljufout, T. (2022). Effects of climate change on water resources: a case study of the Wadi Al-Arab catchment area in Jordan. Environmental Earth Sciences, 81(21), 501.
- IUCN (2020a). Global Standard for Nature-based Solutions. A user-friendly framework for the verification, design and scaling up of NbS. First edition. Gland, Switzerland: IUCN. https://portals.iucn.org/library/node/49071
- IUCN (2020b). Guidance for using the IUCN Global Standard for Nature-based Solutions. A user-friendly framework for the verification, design and scaling up of Nature-based Solutions. First edition. Gland, Switzerland: IUCN. https://portals.iucn.org/library/node/49071
- Kosel, S., Teff-Seker, Y., Orenstein, D. E., & Groner, E. (2020). Narratives of cooperative ecological science: The case of Israel and Jordan. *Peace and Conflict: Journal of Peace Psychology*, *26*(3), 257.
- Lilli et al., (2024). “The Role of Soil Aggregation in the Critical Zone” in book: Critical Zone and Ecosystem Dynamics. DOI : 10.1007/978-3-031-69076-1
- Maragkaki et al., (2024). Optimizing the water-ecosystem-food nexus using nature-based solutions at the basin scale. Frontiers in Water (6). https://doi.org/10.3389/frwa.2024.1386925
- Seddon, N., Chausson, A., Berry, P., Girardin, C. A., Smith, A., & Turner, B. (2020). Understanding the value and limits of nature-based solutions to climate change and other global challenges. Philosophical Transactions of the Royal Society B, 375(1794), 20190120.

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

- Somarakis, G.; Stagakis, S.; Chrysoulakis, N. ThinkNature/Nature-Based Solutions Handbook; European Union: Brussels, Belgium, 2019.
- United Nations, 2015. Transforming our world: the 2030 Agenda for Sustainable Development. A/RES/70/1. United Nations General Assembly, 21 October 2015. https://documents.un.org/doc/undoc/gen/n15/291/89/pdf/n1529189.pdf
- Vanino, S.; Baratella, V.; Pirelli, T.; Ferrari, D.; Di Fonzo, A.; Pucci, F.; Nikolaidis, N.P.; Lilli, M.A.; Dogan, Z.A.; Topdemir, T.; et al. Nature-Based Solutions for Optimizing the Water–Ecosystem–Food Nexus in Mediterranean Countries. Sustainability 2024, 16, 4064. https://doi.org/10.3390/su16104064

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

Annex: List of all reviewed articles and review articles

Authors	Article Title	Journal Abbreviation	Publication Year	DOI
Guelmami, A	Large-scale mapping of existing and lost wetlands: Earth Observation data and tools to support restoration in the Sebou and Medjerda river basins	EURO-MEDITERR J ENVI	2024	10.1007/s41207-023-00443-6
Jódar, J et al.	Artificial recharge by means of careo channels versus natural aquifer recharge in a semi-arid, high-mountain watershed (Sierra Nevada, Spain)	SCI TOTAL ENVIRON	2022	10.1016/j.scitotenv.2022.153937
Campos, JC et al.	Using fire to enhance rewilding when agricultural policies fail	SCI TOTAL ENVIRON	2021	10.1016/j.scitotenv.2020.142897
Cristiano, E et al.	Analysis of potential benefits on flood mitigation of a CAM green roof in Mediterranean urban areas	BUILD ENVIRON	2020	10.1016/j.buildenv.2020.107179
Grace, M et al.	Priority knowledge needs for implementing nature-based solutions in the Mediterranean islands	ENVIRON SCI POLICY	2021	10.1016/j.envsci.2020.10.003
Everard, M et al.	Livelihood security enhancement though innovative water management in dryland India	WATER INT	2021	10.1080/02508060.2021.1874780
Hou, J et al.	Applying Trait-Based Modeling to Achieve Functional Targets during the Ecological Restoration of an Arid Mine Area	AGRONOMY-BASEL	2022	10.3390/agronomy12112833
Hart, TGB	The significance of African vegetables in ensuring food security for South Africa's rural poor	AGR HUM VALUES	2011	10.1007/s10460-010-9256-z

Authors	Article Title	Journal Abbreviation	Publication Year	DOI
Chàfer, M et al.	Greenery System for Cooling Down Outdoor Spaces: Results of an Experimental Study	SUSTAINABILITY-BASEL	2020	10.3390/su12155888
Turconi, L et al.	Implementation of Nature-Based Solutions for Hydro-Meteorological Risk Reduction in Small Mediterranean Catchments: The Case of Portofino Natural Regional Park, Italy	SUSTAINABILITY-BASEL	2020	10.3390/su12031240
Ljubojevic, M	Horticulturalization of the 21st century cities	SCI HORTIC-AMSTERDAM	2021	10.1016/j.scienta.2021.110350
Masiero, M et al.	Riparian Forests as Nature-Based Solutions within the Mediterranean Context: A Biophysical and Economic Assessment for the Koiliaris River Watershed (Crete, Greece)	FORESTS	2024	10.3390/f15050760
Ostoic, SK et al.	Urban forest research in the Mediterranean: A systematic review	URBAN FOR URBAN GREE	2018	10.1016/j.ufug.2018.03.005
Bigurra-Alzati, CA et al.	Water Conservation and Green Infrastructure Adaptations to Reduce Water Scarcity for Residential Areas with Semi-Arid Climate: Mineral de la Reforma, Mexico	WATER-SUI	2021	10.3390/w13010045
Yahya, F et al.	Decentralized Wetland-Aquaponics Addressing Environmental Degradation and Food Security Challenges in Disadvantaged Rural Areas: A Nature-Based Solution Driven by Mediterranean Living Labs	SUSTAINABILITY-BASEL	2023	10.3390/su152015024

Authors	Article Title	Journal Abbreviation	Publication Year	DOI
Schneider-Valenzuela, I et al.	Nature-based Solutions (NbS) for addressing water scarcity in the Mediterranean Ecoregion of Chile	REV GEOGR NORTE GD	2023	
Cerdà, A et al.	Is the hillslope position relevant for runoff and soil loss activation under high rainfall conditions in vineyards?	ECOHYDROL HYDROBIOL	2020	10.1016/j.ecohyd.2019.05.006
Estelrich, M et al.	Feasibility of vertical ecosystem for sustainable water treatment and reuse in touristic resorts	J ENVIRON MANAGE	2021	10.1016/j.jenvman.2021.112968
Marando, F et al.	Urban heat island mitigation by green infrastructure in European Functional Urban Areas	SUSTAIN CITIES SOC	2022	10.1016/j.scs.2021.103564
Eekhout, JPC et al.	The impact of reservoir construction and changes in land use and climate on ecosystem services in a large Mediterranean catchment	J HYDROL	2020	10.1016/j.jhydrol.2020.125208
Singh, PK et al.	Pathways for climate change adaptations in arid and semi-arid regions	J CLEAN PROD	2021	10.1016/j.jclepro.2020.124744
Cortegano, M et al.	'Mertola, a lab for the future' as a transformational plan for the mediterranean semi-arid region: A learning case based on landsenses ecology	INT J SUST DEV WORLD	2021	10.1080/13504509.2021.1920059
Huang, QL et al.	Predicting the geographical distribution and niche characteristics of Cotoneaster multiflorus based on future climate change	FRONT PLANT SCI	2024	10.3389/fpls.2024.1360190

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

Authors	Article Title	Journal Abbreviation	Publication Year	DOI
Qi, QQ et al.	Construction and Application of a Seasonal River Health Evaluation System in Arid and Semi-Arid Areas	WATER-SUI	2024	10.3390/w16050691
Reyes-Paecke, S et al.	Irrigation of green spaces and residential gardens in a Mediterranean metropolis: Gaps and opportunities for climate change adaptation	LANDSCAPE URBAN PLAN	2019	10.1016/j.landurbplan.2018.10.006
León-Lobos, P et al.	The role of ex situ seed banks in the conservation of plant diversity and in ecological restoration in Latin America	PLANT ECOL DIVERS	2012	10.1080/17550874.2012.713402
Hong, Z et al.	Conservation Agriculture for Environmental Sustainability in A Semiarid Agroecological Zone under Climate Change Scenarios	SUSTAINABILITY-BASEL	2018	10.3390/su10051430
Yue, YJ et al.	Research on land use optimization for reducing wind erosion in sandy desertified area: a case study of Yuyang County in Mu Us Desert, China	STOCH ENV RES RISK A	2017	10.1007/s00477-016-1223-9
Liu, YF et al.	Trade-off between surface runoff and soil erosion during the implementation of ecological restoration programs in semiarid regions: A meta-analysis	SCI TOTAL ENVIRON	2020	10.1016/j.scitotenv.2019.136477
Atamian, HS et al.	Physiological and transcriptomic responses of two Artemisia californica populations to drought: implications for restoring drought-resilient native communities	GLOB ECOL CONSERV	2023	10.1016/j.gecco.2023.e02466

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

Authors	Article Title	Journal Abbreviation	Publication Year	DOI
Badiane, A et al.	Use of compost and mineral fertilizers for millet production by farmers in the semiarid region of Senegal	BIOL AGRIC HORTIC	2001	10.1080/01448765.2001.9754926
Ruthrof, KX et al.	Linking restoration outcomes with mechanism: the role of site preparation, fertilisation and revegetation timing relative to soil density and water content	PLANT ECOL	2013	10.1007/s11258-013-0224-8
BECKER, R et al.	ALTERNATIVE CROPS FOR SUSTAINABLE AGRICULTURAL SYSTEMS	AGR ECOSYST ENVIRON	1992	10.1016/0167-8809(92)90097-U
Maaz, T et al.	Economic, policy, and social trends and challenges of introducing oilseed and pulse crops into dryland wheat cropping systems	AGR ECOSYST ENVIRON	2018	10.1016/j.agee.2017.03.018
Benayas, JMR et al.	Potential of pest regulation by insectivorous birds in Mediterranean woody crops	PLOS ONE	2017	10.1371/journal.pone.0180702
Vidal, A et al.	The emergence of agroecological practices on agropastoral dairy farms in the face of changing demand from dairies	BIOTECHNOL AGRON SOC	2020	
Bosire, CK et al.	Adaptation opportunities for smallholder dairy farmers facing resource scarcity: Integrated livestock, water and land management	AGR ECOSYST ENVIRON	2019	10.1016/j.agee.2019.106592
García-Herrero, L et al.	Cost-benefit of green infrastructures for water management: A sustainability assessment of full-scale constructed wetlands in Northern and Southern Italy	ECOL ENG	2022	10.1016/j.ecoleng.2022.106797

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

Authors	Article Title	Journal Abbreviation	Publication Year	DOI
Raji, SA et al.	Quantifying ecosystem service interactions to support environmental restoration in a tropical semi-arid basin	ACTA GEOPHYS	2021	10.1007/s11600-021-00644-z
de Oliveira, FL et al.	Conceptualising nature-based solutions: addressing environmental challenges in the city of Amman, Jordan	URBAN RES PRACT	2024	10.1080/17535069.2024.2313211
Malamis, S et al.	Recovering Non-Conventional Water Sources in the Mediterranean: The HYDROUSA Project Experience	ERCIM NEWS	2021	
Mercer, J et al.	Ecosystem-Based Adaptation for Food Security in the AIMS SIDS: Integrating External and Local Knowledge	SUSTAINABILITY-BASEL	2014	10.3390/su6095566
Aslan, CE et al.	Management thresholds stemming from altered fire dynamics in present-day arid and semi-arid environments	J ENVIRON MANAGE	2018	10.1016/j.jenvman.2018.08.079
Piacentini, SM et al.	Attitude and Actual Behaviour towards Water-Related Green Infrastructures and Sustainable Drainage Systems in Four North-Western Mediterranean Regions of Italy and France	WATER-SUI	2020	10.3390/w12051474
Depietri, Y et al.	Fire-Regulating Services and Disservices With an Application to the Haifa-Carmel Region in Israel	FRONT ENV SCI-SWITZ	2019	10.3389/fenvs.2019.00107
Casey, L et al.	Comparative environmental footprints of lettuce supplied by hydroponic controlled-environment agriculture and field-based supply chains	J CLEAN PROD	2022	10.1016/j.jclepro.2022.133214

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

Authors	Article Title	Journal Abbreviation	Publication Year	DOI
Aurelle, D et al.	Biodiversity, climate change, and adaptation in the Mediterranean	ECOSPHERE	2022	10.1002/ecs2.3915
Guo, SS et al.	An integrated distributed robust optimization framework for agricultural water-food-energy management integrating ecological impact and dynamic water cycle processes	J HYDROL	2023	10.1016/j.jhydrol.2023.129859
Bryan, E et al.	Can agriculture support climate change adaptation, greenhouse gas mitigation and rural livelihoods? insights from Kenya	CLIMATIC CHANGE	2013	10.1007/s10584-012-0640-0
Lyu, X et al.	A Perspective on the Impact of Grassland Degradation on Ecosystem Services for the Purpose of Sustainable Management	REMOTE SENS-BASEL	2022	10.3390/rs14205120
Pueyo-Ros, J et al.	Beyond food: A stochastic model to estimate the contributions of urban agriculture to sustainability	LANDSCAPE URBAN PLAN	2024	10.1016/j.landurbplan.2023.104930
Arrar, HF et al.	Coupling of different nature base solutions for pedestrian thermal comfort in a Mediterranean climate	BUILD ENVIRON	2024	10.1016/j.buildenv.2024.111480
Zanin, GM et al.	Nature-based solutions for coastal risk management in the Mediterranean basin: A literature review	J ENVIRON MANAGE	2024	10.1016/j.jenvman.2024.120667
Romero, P et al.	Nature-Based Solutions for Optimizing the Water-Ecosystem-Food Nexus in Mediterranean Countries	SUSTAINABILITY-BASEL	2024	10.3390/su16104064
Couch, VT et al.	De-Sealing Reverses Habitat Decay More Than Increasing Groundcover Vegetation	CLIMATE	2023	10.3390/cli11060116

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

Authors	Article Title	Journal Abbreviation	Publication Year	DOI
Carabassa, V et al.	Water-saving techniques for restoring desertified lands: Some lessons from the field	LAND DEGRAD DEV	2022	10.1002/ldr.4134
Pumo, D et al.	The potential of multilayer green roofs for stormwater management in urban area under semi-arid Mediterranean climate conditions	J ENVIRON MANAGE	2023	10.1016/j.jenvman.2022.116643
Nabhan, GP et al.	An Aridamerican model for agriculture in a hotter, water scarce world	PLANTS PEOPLE PLANET	2020	10.1002/ppp3.10129
Wang, JG et al.	Spatio-temporal variations and drivers of ecological carrying capacity in a typical mountain-oasis-desert area, Xinjiang, China	ECOL ENG	2022	10.1016/j.ecoleng.2022.106672
Jiang, B et al.	Improved vegetation greenness increases summer atmospheric water vapor over Northern China	J GEOPHYS RES-ATMOS	2013	10.1002/jgrd.50602
Eekhout, JPC et al.	How future changes in irrigation water supply and demand affect water security in a Mediterranean catchment	AGR WATER MANAGE	2024	10.1016/j.agwat.2024.108818
Huang, J et al.	Climate change and ecological engineering jointly induced vegetation greening in global karst regions from 2001 to 2020	PLANT SOIL	2022	10.1007/s11104-021-05054-0
Dube, K et al.	Mapping and evaluating the impact of flood hazards on tourism in South African national parks	J OUTDOOR REC TOUR	2023	10.1016/j.jort.2023.100661
Delgado-Capel, M et al.	Towards a Standard Framework to Identify Green Infrastructure Key Elements in Dense Mediterranean Cities	FORESTS	2020	10.3390/f11121246

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

Authors	Article Title	Journal Abbreviation	Publication Year	DOI
Zaimes, GN	Mediterranean Riparian Areas-Climate change implications and recommendations	J ENVIRON BIOL	2020	10.22438/jeb/41/5/MRN-1454
Deeb, M et al.	The urgency of building soils for Middle Eastern and North African countries: Economic, environmental, and health solutions	SCI TOTAL ENVIRON	2024	10.1016/j.scitotenv.2024.170529
Andrade, M et al.	Urban Green Infrastructure: Does Species' Origin Impair Ecosystem Services Provision?	LAND-BASEL	2024	10.3390/land13010023
Robson, T et al.	Enhancing tailings revegetation using shallow cover systems in arid environments: Hydrogeochemical, nutritional, and ecophysiological constraints	LAND DEGRAD DEV	2018	10.1002/ldr.2980
Félix, GF et al.	Use and management of biodiversity by smallholder farmers in semi-arid West Africa	GLOB FOOD SECUR-AGR	2018	10.1016/j.gfs.2018.08.005
Golpaygani, A et al.	Optimal selection of cost-effective biological runoff management scenarios at watershed scale using SWAT-GA tool	J HYDROL-REG STUD	2023	10.1016/j.ejrh.2023.101489
Noumi, Z	Can native shrubs facilitate the establishment of trees under arid bioclimate? A case study from Tunisia	FLORA	2020	10.1016/j.flora.2019.151517
Hale, RL et al.	iSAW: Integrating Structure, Actors, and Water to study socio-hydro-ecological systems	EARTHS FUTURE	2015	10.1002/2014EF000295
Endreny, TA et al.	Ancient eco-technology of qanats for engineering a sustainable water supply in the Mediterranean Island of Cyprus	ENVIRON GEOL	2009	10.1007/s00254-008-1274-4

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

Authors	Article Title	Journal Abbreviation	Publication Year	DOI
Song, YF et al.	The responses of three dominant species to increased rainfall under different grazing systems in a desert steppe	HYDROL PROCESS	2022	10.1002/hyp.14632
Hulvey, KB et al.	Restoration islands: a tool for efficiently restoring dryland ecosystems?	RESTOR ECOL	2017	10.1111/rec.12614
Hrameche, O et al.	Optimizing Agroecological Measures for Climate-Resilient Olive Farming in the Mediterranean	PLANTS-BASEL	2024	10.3390/plants13060900
Leauthaud, C et al.	Adoption factors and structural characteristics of irrigated olive grove agroforestry systems in Central Tunisia	AGROECOL SUST FOOD	2022	10.1080/21683565.2022.2085230
López, JA	Nature-based solutions for mitigating the impact of climate change and the effect of the Sahara Desert on Mediterranean agriculture	REV ESP ESTUD AGROSO	2024	10.24197/reeap.262.2024.130-166
Alba-Patiño, D et al.	Social indicators of ecosystem restoration for enhancing human wellbeing	RESOUR CONSERV RECY	2021	10.1016/j.resconrec.2021.105782
Kakoulas, DA et al.	The Effectiveness of Rainwater Harvesting Infrastructure in a Mediterranean Island	WATER-SUI	2022	10.3390/w14050716
Petzold, J et al.	Between tinkering and transformation: A contemporary appraisal of climate change adaptation research on the world's islands	FRONT CLIM	2023	10.3389/fclim.2022.1072231
Tian, HJ et al.	Response of vegetation activity dynamic to climatic change and ecological restoration programs in Inner Mongolia from 2000 to 2012	ECOL ENG	2015	10.1016/j.ecoleng.2015.04.098

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

Authors	Article Title	Journal Abbreviation	Publication Year	DOI
Su, DH et al.	Distribution and transformation characteristics of water vapor field in the fissured rock mass and its ecological significance	J HYDROL	2024	10.1016/j.jhydrol.2024.130785
Steed, A et al.	Response of arthropod communities to plant-community rehabilitation efforts after strip mining on the semi-arid west coast of South Africa	AFR J RANGE FOR SCI	2018	10.2989/10220119.2018.1518486
Jiang, C et al.	Integrating ecosystem services into effectiveness assessment of ecological restoration program in northern China's arid areas: Insights from the Beijing-Tianjin Sandstorm Source Region	LAND USE POLICY	2018	10.1016/j.landusepol.2018.03.018
Zhang, HB et al.	Wind Speed and Vegetation Coverage in Turn Dominated Wind Erosion Change With Increasing Aridity in Africa	EARTHS FUTURE	2024	10.1029/2024EF004468
Rosas-Ramos, N et al.	The complementarity between ecological infrastructure types benefits natural enemies and pollinators in a Mediterranean vineyard agroecosystem	ANN APPL BIOL	2019	10.1111/aab.12529
Saaroni, H et al.	Urban Green Infrastructure as a tool for urban heat mitigation: Survey of research methodologies and findings across different climatic regions	URBAN CLIM	2018	10.1016/j.uclim.2018.02.001
Li, XW et al.	Changes in Vegetation Coverage and Migration Characteristics of Center of Gravity in the Arid Desert Region of Northwest China in 30 Recent Years	LAND-BASEL	2022	10.3390/land11101688

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

Authors	Article Title	Journal Abbreviation	Publication Year	DOI
Stephens, SL et al.	Operational approaches to managing forests of the future in Mediterranean regions within a context of changing climates	ENVIRON RES LETT	2010	10.1088/1748-9326/5/2/024003
Cuthbert, MO et al.	Global climate-driven trade-offs between the water retention and cooling benefits of urban greening	NAT COMMUN	2022	10.1038/s41467-022-28160-8
Reckling, M et al.	Diversification for sustainable and resilient agricultural landscape systems	AGRON SUSTAIN DEV	2023	10.1007/s13593-023-00898-5
De Luca, AI et al.	A methodological proposal of the Sustainolive international research project to drive Mediterranean olive ecosystems toward sustainability	FRONT SUSTAIN FOOD S	2023	10.3389/fsufs.2023.1207972
Yang, JC et al.	Planning for a sustainable desert city: The potential water buffering capacity of urban green infrastructure	LANDSCAPE URBAN PLAN	2017	10.1016/j.landurbplan.2017.07.014
Cao, SX	Impact of China's Large-Scale Ecological Restoration Program on the Environment and Society in Arid and Semiarid Areas of China: Achievements, Problems, Synthesis, and Applications	CRIT REV ENV SCI TEC	2011	10.1080/10643380902800034
Abouaiana, A et al.	Retrofitting Dwellings in Traditional Coastal Settlements in Egypt and Portugal Using Nature-Based Solutions and Conventional Thermal Insulation Materials: Technical and Economic Assessment	J ARCHIT ENG	2022	10.1061/(ASCE)AE.1943-5568.0000537

Authors	Article Title	Journal Abbreviation	Publication Year	DOI
Zhang, XY et al.	Optimizing spatial layout of afforestation to realize the maximum benefit of water resources in arid regions: A case study of Alxa, China	J CLEAN PROD	2021	10.1016/j.jclepro.2021.128827
Delgado-Capel, MJ et al.	Capacity of Urban Green Infrastructure Spaces to Ameliorate Heat Wave Impacts in Mediterranean Compact Cities: Case Study of Granada (South-Eastern Spain)	LAND-BASEL	2023	10.3390/land12051076
Barredo, JI et al.	Mediterranean habitat loss under future climate conditions: Assessing impacts on the Natura 2000 protected area network	APPL GEOGR	2016	10.1016/j.apgeog.2016.08.003
Romero, P et al.	Towards a sustainable viticulture: The combination of deficit irrigation strategies and agroecological practices in Mediterranean vineyards. A review and update	AGR WATER MANAGE	2022	10.1016/j.agwat.2021.107216
Nunes, A et al.	Ecological restoration across the Mediterranean Basin as viewed by practitioners	SCI TOTAL ENVIRON	2016	10.1016/j.scitotenv.2016.05.136
Wai, CY et al.	A Systematic Review on the Existing Research, Practices, and Prospects Regarding Urban Green Infrastructure for Thermal Comfort in a High-Density Urban Context	WATER-SUI	2022	10.3390/w14162496
Bradshaw, SD et al.	Little evidence for fire-adapted plant traits in Mediterranean climate regions	TRENDS PLANT SCI	2011	10.1016/j.tplants.2010.10.007

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

Authors	Article Title	Journal Abbreviation	Publication Year	DOI
Wang, G et al.	Regulated Ecosystem Services Trade-Offs: Synergy Research and Driver Identification in the Vegetation Restoration Area of the Middle Stream of the Yellow River	REMOTE SENS-BASEL	2022	10.3390/rs14030718
Young, KE et al.	Restoration research actions to address rapid change in drylands: insights from the Colorado Plateau	RESTOR ECOL	2023	10.1111/rec.13855

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].

Project Coordinator

Project Partners

This publication reflects only the author's view and the PRIMA Foundation is not responsible for any use that may be made of the information it contains

This project is part of the PRIMA programme supported by the European Union. GA n° [2243] [EcoFuture] [Call 2022 Section 1 NEXUS WEFE IA].