A WEFE Nexus Agricultural Transformation Strategy for Jordan and Palestine

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The strategy at-a-glance

Why this matters

- The Jordan Valley (JV) is highly vulnerable to climate change, desertification and water scarcity, threatening food security and livelihoods.
- Salinization, degraded soils, and small farm sizes undermine productivity and profitability.
- The poorest and most vulnerable communities — including displaced people and those in informal settlements — suffer most from limited water and agricultural resources.
- Without urgent action, socio-economic instability will deepen.

What the EcoFuture Strategic Plan Offers

The EcoFuture Strategic Plan provides a joint, foresight-informed strategy for the Jordanian and Palestinian parts of the Jordan Valley, translating the WEFE nexus into concrete policy directions and investment priorities. Developed through scientific analysis and participatory stakeholder engagement, the Plan moves beyond incremental optimisation and defines a coherent transformation pathway toward climate-resilient, resource-efficient and regenerative development.

The New Agricultural Transformation Strategy (ATS)

At the core of the Strategic Plan is the Agricultural Transformation Strategy, which recognises agriculture as a key pressure point and the highest-leverage entry point for improving WEFE outcomes. The ATS represents a shift toward an integrated, regenerative and resource-efficient agricultural paradigm, addressing water, energy, food and ecosystem challenges simultaneously.

Key measures and impacts

- **Smart irrigation and soil-moisture monitoring**, reducing water use by up to 41%
- **Soil organic matter restoration**, increasing yields by up to 35% and enhancing water retention
- **Rainwater harvesting from greenhouses**, with a potential supply of 6–10 million m^3/yr (Jordan)
- **Decentralised wastewater treatment and reuse in Palestine**, supplying ~2 million m^3/year of irrigation water
- **Circular organic resource management**, capable of covering fertiliser needs fully in Jordan and partially in Palestine, substantially reducing dependency on imports
- **Small-scale, renewable energy integration**, improving on-farm resilience and economic viability

The Opportunity

By implementing these measures, the JV can:

- Secure food and water for its population
- Restore soils and ecosystems while improving productivity
- Strengthen farmer livelihoods and rural economies
- Reduce dependence on costly imports
- Foster cross-border WEFE cooperation, supporting shared resilience and long-term stability
- Position itself as a model for climate-adaptive development in the Mediterranean region

Priority Actions

- Endorse the ATS as a guiding framework for WEFE implementation and policy alignment
- Prioritise demand-side water security measures
- Align incentives and financing with regenerative and circular practices
- Strengthen coordination, extension services and training infrastructure.

Policy Brief for Jordan and Palestine

Policy Brief for Jordan and Palestine

Executive Summary

The Jordan Valley is the agricultural heartland of both Jordan and Palestine and a critical pillar for food security, rural livelihoods and ecosystem services. Yet, it faces escalating challenges from water scarcity, land degradation, and climate change. Over the past four decades, rainfall has declined by up to 33%, average temperatures have risen by 1.9°C, and river inflows to the Dead Sea have decreased by 90%.

The EcoFuture Project—implemented under the PRIMA Programme with national research institutions and regional partners—developed a Strategic Plan based on the WEFE nexus. The Plan articulates a New Agricultural Transformation Strategy (ATS) that moves beyond incremental optimisation and provides a shared, foresight-informed pathway for climate adaptation, resource security and regenerative development in the Jordan Valley.

1. Context and Key Challenges

- **Water Scarcity:** Both Jordanian and Palestinian parts of the Jordan Valley face severe and growing water deficits for irrigation and domestic use. High losses in distribution networks, groundwater over-abstraction and limited use of non-conventional water sources increase vulnerability under climate change.
- **Land Degradation:** High soil salinity, low organic matter, and declining fertility undermine crop yields and accelerate desertification.
- **Energy Constraints:** Agriculture depends on energy-intensive pumping, treatment and irrigation. Rising energy costs and limited access to decentralised renewable solutions reduce economic resilience.
- **Socioeconomic Vulnerability:** Limited access to technology, finance and knowledge resources, and exposure to climate and market shocks disproportionately affect smallholders and vulnerable communities.

2. Evidence from EcoFuture Demonstrations

Pilots in both territories confirm that integrated WEFE solutions deliver tangible benefits:

Intervention	Demonstrated Results
Smart irrigation & rainwater harvesting	29-41% water savings; 135 m^3 collected from six greenhouses over three rain events with ~70% capture efficiency.
Soil carbon enrichment (compost + manure)	Tomato yield increased from 6.5 → 8.8 t/dunum; potential up to 21 t/dunum with higher soil carbon.
Solar-powered desalination	Improved irrigation efficiency and water quality.

Intervention	Demonstrated Results
Circular nutrient management	Organic residues can fully cover fertiliser needs in Jordan and substantially reduce fertiliser imports in Palestine.

These findings confirm that WEFE-based approaches are technically feasible, economically viable and socially inclusive.

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3. Strategic Vision

Vision: A resilient Jordan Valley where integrated management of water, energy, food, and ecosystems ensures long-term resource security, ecological restoration, and socioeconomic prosperity.
Strategic Goals:

1. **Resource Security:** Guarantee sustainable access to water, energy, and food.
2. **Environmental Sustainability:** Regenerate soil health, restore biodiversity, and enhance carbon storage.
3. **Social Prosperity:** Empower farmers, youth, and women through innovation and inclusive markets.

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4. The Agricultural Transformation Strategy (ATS)

At the core of the Strategic Plan, the ATS represents a shift toward an integrated, regenerative and resource-efficient agricultural paradigm. It prioritises:

- demand-side water efficiency and loss reduction,
- soil restoration and agroecological practices,
- circular resource use and nutrient recovery,
- small-scale renewable energy integration, and
- decentralised, farmer-centred solutions supported by training and advisory services.

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5. Policy Directions (2025–2027)

1. Endorse and operationalise the ATS

- Adopt the Agricultural Transformation Strategy as a **shared reference framework** for WEFE implementation in the Jordan Valley, ensuring coherence across agriculture, water, energy and environmental policies and public investment programmes in both territories.

2. Prioritise demand-side water security

- Focus on water loss reduction, smart irrigation, rainwater harvesting and soil-based water retention, delivering rapid, low-regret gains and reducing pressure on groundwater and surface water resources.

3. Mainstream Regenerative and Circular Agriculture

- Align incentives, subsidies and advisory services with soil restoration, organic amendments, wastewater reuse and nutrient recycling, reducing dependence on imported inputs and enhancing resilience.

4. Strengthen capacity, data and learning systems

- Scale up training hubs, demonstration sites and WEFE monitoring platforms to support farmer adoption, institutional learning and adaptive management.

5. Mobilise finance and partnerships

- Use the ATS to guide donor coordination and investment alignment, leveraging climate and development finance and fostering public–private partnerships in irrigation technologies, renewable energy and organic resource recovery.

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6. Expected Outcomes

Implementing the WEFE Strategic Plan will:

- Reduce groundwater abstraction and irrigation demand by up to 41%.
- Increase crop yields by up to 35%.
- Achieve self-sufficiency in organic fertilizers through nutrient recycling.
- Lower energy costs via small-scale solar systems.
- Strengthen farmer livelihoods and resilience across rural communities.

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7. Conclusion

The Jordan Valley stands at a turning point. By institutionalizing WEFE-integrated governance, Jordan can shift from fragmented, reactive management to a coordinated, evidence-based, and forward-looking system. The EcoFuture results provide proof of concept that regenerative, data-driven, and community-led solutions can restore productivity, secure livelihoods, and advance Jordan's commitments under the UNCCD, UNFCCC, and SDG 15.3.

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Executive Summary

Executive Summary

Preamble

The ecosystem of the Jordan Valley (JV), characterized by its rich biodiversity and unique habitats, plays a crucial role in supporting agricultural activities. The JV faces increasing challenges from desertification, a process that degrades fertile land into desert through both natural forces and human activities. This degradation threatens vital ecosystems, agricultural productivity, and the livelihoods of communities across the region. Natural factors such as drought and climate-induced flash floods weaken soil and vegetation, while unsustainable land use practices accelerate soil deterioration.

Addressing these complex challenges requires integrated solutions. The Water-Energy-Food-Ecosystem (WEFE) nexus emerges as a vital framework in this context, emphasizing the interconnectedness of these sectors and the need for a holistic management approach to achieve socioeconomic welfare for the people of the valley.

In this context, the EcoFuture project develops a Strategic Plan for the Jordanian and Palestinian parts of the Jordan Valley that translates the WEFE nexus approach into concrete policy directions and investment priorities. The objective of the Strategic Plan is to define a coherent programme of measures that supports climate-change adaptation, strengthens resource security, enhances ecosystem resilience and improves socio-economic conditions for people living in the JV. Given the largely shared challenges, barriers and opportunities across the two territories, the Strategic Plan is conceived as a common framework, while allowing for territory-specific implementation pathways.

Current situation of the WEFE Nexus

The current situation of the WEFE Nexus in the JV can be summarized as follows:

Water:

- Both territories exhibit significant deficit in the water supply and demand that will increase due to climate change and the expected population growth.
- For both territories, 50% of the water is lost due to leakage in the drinking water network, attributed to inadequate maintenance.
- Water reuse is only 1% of the total irrigated water in the Palestinian section of the JV and it has therefore the potential to increase substantially, providing a source of water and reducing the deficit.
- Water security in the Jordanian and Palestinian part of the JV is very vulnerable since they rely mostly on local surface and ground water sources and in the case of Jordan on Wastewater Treatment Plant (WWTP) reuse.

Energy:

- The supply of energy in the two territories is meeting the current demand. However, the annual increase in electricity demand in the two countries is increasing at a very fast pace necessitating strategies that will accomplish sufficient increases in energy supply that will cover the future demand.
- Palestine is heavily dependent on Israel for meeting its energy requirements. Almost all petroleum products and most of the electricity are imported from Israel and the possibility of diversifying the energy development and imports from other countries is currently limited due to political constraints as Israel controls 60% of the West Bank.
- JV can be a great source of renewable energy, far more than the local JV demand.

Food:

- The JV serves as the primary food production area for both Jordan and Palestine, acting as their agricultural food basket.
- Serious issues have been identified in the food sector that need to be addressed. The agricultural land has been degraded due to continuous cultivation for millennia which has as a result extremely low soil organic carbon. The impact of this situation is depicted in the estimated crop yields. This is a common problem necessitating measures for soil restoration using agroecological practices and active carbon additions to soils that will improve soil quality, fertility and health.
- Climate change and several biotic and abiotic stresses challenge the growth and production of agricultural crops. Among abiotic stresses, soil salinity is considered as one of the leading limiting factors responsible for growth and production decline of agricultural crops. The progressively increasing soil salinity threatens the sustainability of irrigated agriculture in the central and southern regions of the JV. This increase is attributed to unsustainable agricultural practices and inputs, quality of irrigation water, lack of advanced irrigation technologies and efficient drainage systems, and improper land management.
- Population growth and rapid urbanization have increased the pressure on the agriculture sector. The growing gap between local production and consumption has made imports increasingly essential to meet food needs.

Environment:

- The JV is a vital and diverse environment, encompassing various ecosystems, including freshwater, shrublands, drylands, agricultural and urban ecosystems in a sub-tropical climate. It serves as the biological heart of the Middle East, supporting its unique flora and fauna, and acting as an important migratory pathway for birds travelling between Africa and Europe.
- The main drivers that affect the system in the area are climate change, population growth, land use change and pollution. The environmental pressures exerted in the JV are the result of intensive agricultural activities (agriculture, livestock), tourism, climate change, geogenic pollution, population growth, migration and invasive species. These pressures have resulted in significant impacts to the WEFE Nexus with surface water flow decline, groundwater depletion, high groundwater salinity, pollution and loss of biodiversity.
- Significant surface and groundwater flow declines have been observed in the Jordan River and the discharge to the Dead Sea has been decreasing dramatically leading to the water level declines over the years.
- The main sources of pollution in the JV are wastewater from treatment plants and unsewered areas, fertilizer (including unfermented manure), pesticide and herbicide pollution from agriculture, urban solid waste disposal sites, and small "industrial" facilities mostly related to agriculture.
- Climate change has been projected as a serious threat to the area. The region's climate is changing, with the potential for increased droughts, higher temperatures and more extreme weather events, posing significant challenges to the preservation of ecosystem.

Strategic Plan Vision

The overarching objective of the EcoFuture project is to develop a climate-change adaptation program to combat desertification oriented towards improving socio-economic welfare for people in the JV by means of policy interventions articulating WEFE nexus dynamics.

The partners of the EcoFuture project envision the JV as a region where WEFE resource integration ensures resource security, enhances environmental and public health, and maximizes socio-economic prosperity for its people.

Strategic Goals (SGs)

SG 1 – Resource security: Ensure security of Water-Energy-Food (WEF) supply

To ensure the security of water, energy, and food supply in the face of growing climate, environmental, and socio-political pressures, a strategic plan must adopt integrated, sustainable, and resilient approaches across all levels of governance and society. The following operational objectives outline the core pillars of such a strategic plan:

1. **Inclusive and Sustainable Resource Management.**
2. **Infrastructure Resilience and Investment**.
3. **Policy Integration and Governance.**
4. **Innovation and Technology**.
5. **Public Awareness and Stakeholder Engagement**.
6. **Adaptive Preparedness, Monitoring, and Response**.

SG 2 –Environmental Sustainability: Improve Environmental and Public Health

To achieve environmental sustainability and improve environmental and public health, a strategic plan should include objectives that focus on reducing environmental degradation, protecting ecosystems, and minimizing health risks from pollution and climate change. The following objectives outline the key pillars of such a strategic plan focused on environmental protection and health resilience:

1. **Pollution and Waste Reduction through a Circular Economy.**
2. **Climate Action and Resilient Ecosystems.**
3. **Sustainable Land, Water, and Urban Systems.**
4. **Sustainable Agriculture and Food Systems**.
5. **Environmental Health Protection and Disease Prevention.**
6. **Education, Engagement, and Evidence-Based Governance**.

SG 3 – Socio-Economic Prosperity: Improve the Economic Viability of the JV

To promote socio-economic prosperity and improve economic viability, a strategic plan should focus on inclusive, resilient, and sustainable economic growth. The following objectives define a roadmap to foster long-term prosperity and socio-economic stability.

1. **Inclusive and Resilient Economic Growth.**
2. **Economic Diversification and Innovation**.
3. **Education, Skills Development, and Workforce Readiness**.
4. **Infrastructure Development**.
5. **Sustainable Business Environment and Market Access.**
6. **Good Governance and Environmental Integration.**

Program of Measures

To operationalise the Strategic Goals, a comprehensive set of potential WEFE interventions was identified through the EcoFuture strategic planning framework and refined in close collaboration with Jordanian and Palestinian stakeholders. The resulting programme of measures spans water security, energy transition, food production and ecosystem restoration, and reflects both scientific evidence and local feasibility considerations.

The proposed measures address key system pressures by prioritising demand-side water management and efficiency (e.g. water loss reduction, smart irrigation, rainwater harvesting), regenerative agricultural practices that restore soil health and productivity (e.g. carbon addition, agroforestry and terracing), circular resource use through organic waste recovery and fertiliser substitution, renewable energy integration in agricultural systems, and targeted ecosystem protection and restoration actions.

Rather than treating measures in isolation, the programme emphasises complementarities and cross-sectoral synergies across the WEFE nexus, laying the foundation for integrated implementation pathways. This initial portfolio of measures does not represent a final selection but serves as the analytical basis for systematic evaluation and prioritisation.

All measures were subsequently assessed and prioritised through a participatory Multi-Criteria Decision Analysis (MCDA) process, ensuring that the final set of priority interventions reflects environmental performance, socio-economic benefits, implementation feasibility and stakeholder preferences. The outcomes of this prioritisation process form the core of the Agricultural Transformation Strategy presented in the following sections.

Prioritizing WEFE Measures

MCDA methodology

Selecting the most appropriate WEFE interventions for the JV is a complex decision-making challenge, calling for a method that can handle multiple objectives and diverse stakeholder perspectives. To meet this need, the EcoFuture project applied MCDA as a structured participatory approach widely used in sustainability planning.

The goal of the MCDA process was to assess and rank alternative measures based on their expected performance across multiple criteria and diverse stakeholder perspectives. A comprehensive criteria framework was developed, informed by scientific literature, global sustainability standards, and insights from local stakeholders. It included four main categories of criteria:

- Key challenges & environmental sustainability
- Social equity, community empowerment & well-being
- Economic benefits & affordability
- Implementation feasibility & operational sustainability

Each measure was scored on a standardized qualitative scale (-3 to +3) across all criteria, with evaluations performed by the project's expert team and validated by local partners. To reflect stakeholder priorities, a participatory weighting exercise was conducted during the transnational living lab using the Simos method, a visual and intuitive card-based technique for eliciting preferences.

Transnational Living Lab in Jordan

To support collaborative planning across the transboundary JV, the Jordanian-Palestinian Transnational Living Lab (TLL) was held in April 2025. Bringing together experts, policymakers, and farmers, the workshop aimed to co-assess and prioritize WEFE measures that address the region's intertwined challenges. Participants engaged in a participatory MCDA process, where they:

- Reviewed and refined the set of alternative WEFE measures,
- Validated or adapted performance assessments to reflect contextual realities.
- Assigned weights to the criteria using the intuitive Simos method, based on their sectoral and national priorities,
- Reviewed the evaluation of the measures using the jointly defined criteria framework.

This process fostered a shared understanding of implementation barriers, and enabled the co-creation of locally grounded, cross-sectoral strategies to guide national and regional planning.

MCDA results

The decision algorithm was then applied to rank the alternatives, considering their performance across the complete set of weighted criteria. To enhance the robustness of the ranking process, two complementary decision logics were applied:

- a fully compensatory logic, which aggregates performance across all criteria and rewards strong overall contributions (Weighted Sum Method – WSM);
- a non-compensatory, reference-point logic, which penalises poor performance on highly weighted criteria and favours balanced solutions (Minimax method).

The application of both logics provides important strategic insights. Measures that perform well under both approaches can be considered robust priorities, as they combine high overall contribution with acceptable minimum performance across critical dimensions such as water security, food security, and income generation.

To further test robustness, sensitivity analysis was conducted by systematically varying criteria weights around the stakeholder-defined baseline. The results demonstrate high stability in the ranking of top-performing measures, indicating that the prioritisation is robust to plausible variations in stakeholder preferences. Robust top-performing groups were identified for each method (WSM and Minimax), and their intersection was used to derive a consistent subset of 13 measures that remains highly ranked across both aggregation logics and all weight perturbations. This subset is resilient to both preference uncertainty and methodological uncertainty. It represents the most reliable portfolio of measures for further analysis and stakeholder deliberation and forms the core of the new Agricultural Transformation Strategy.

The Agricultural Transformation Strategy

The Agricultural Transformation Strategy (ATS) translates the project vision into a coherent transformation pathway for the region under conditions of water scarcity, climate stress, land degradation, and institutional fragmentation, demonstrating that incremental optimisation of current agricultural and resource-management practices is insufficient.

Strategic rationale

Agriculture is both a major driver of WEFE pressures and the highest-leverage entry point for change in the Jordan Valley. The ATS is built on three premises:

1. Agricultural transformation is essential for WEFE security, because water, energy, food and ecosystems are deeply interdependent and cannot be sustainably addressed in isolation.
2. Incremental optimisation is insufficient under climate and geopolitical stress, requiring a qualitative shift in practices, incentives, governance and support systems.
3. Regenerative and nature-based approaches provide high leverage under uncertainty, combining adaptability, lower capital intensity, and resilience.

Core characteristics of the ATS

The ATS departs from input-intensive and fragmented development models and is defined by an integrated WEFE nexus approach that prioritises cross-sector synergies over single-sector optimisation. It is grounded in regenerative and nature-based practices that restore soil health, biodiversity and ecosystem functioning, while emphasising demand reduction, loss minimisation and smart use of water and energy before supply expansion. The strategy embeds circular resource use through nutrient and material recovery, promotes decentralised and locally adaptable solutions suited to smallholder and constrained contexts, and explicitly integrates socio-economic viability by addressing affordability, farmer incomes and capacity building as core conditions for sustainability.

Key areas and measures

The ATS synthesises the robust, top-performing MCDA measures into a strategic package structured around: water security and efficiency, circular resource recovery, renewable energy integration, agro-ecological regeneration, and ecosystem restoration. Priority measures include (indicatively): smart irrigation and soil-moisture monitoring (W2.1–W2.2), rainwater harvesting from greenhouses (W3.1), decentralised wastewater treatment and reuse (W5.1), biomass/organic waste collection and organic fertiliser production (E3.1–E3.2), and regenerative practices such as compost/biochar application and agroforestry/permaculture approaches (F1.1–F1.2), combined with selected ecosystem restoration actions.

Expected impacts

This section synthesises the expected and observed impacts of selected priority measures within the Agricultural Transformation Strategy for Jordan and Palestine, drawing on modelling work, pilot demonstrations and stakeholder deliberations conducted within the EcoFuture project.

- Smart irrigation and water efficiency: Pilot monitoring and HYDRUS-1D modelling show that conventional irrigation often exceeds crop requirements, with 40–53% of applied water percolating below the root zone. Smart irrigation based on soil-moisture data reduces irrigation rates by 40%, with actual crop water use estimated at 90–170 m^3/dunum (well below the ~400 m^3/dunum often recommended in guidelines).
- Rainwater harvesting from greenhouses: Pilot results demonstrate capture efficiencies of ~70%; scaling indicates a potential supply of ~6–10 million m^3/year in the Jordanian part of the Valley, providing a strategic, stabilisation-oriented source of non-conventional water that reduces pressure on groundwater under high water scarcity conditions.
- Soil organic matter restoration (compost/biochar): Pilots and regional evidence indicate strong co-benefits for productivity and water retention. In EcoFuture pilots, tomato yields increased from 6.5 to 8.8 t/dunum. Modelling suggests that a +1% increase in soil organic carbon can increase plant-available water by ~35 m^3/ha, translating to ~7 million m^3/year potential water-saving effects in Jordan and ~4 million m^3/year in Palestine when scaled.
- Decentralised wastewater treatment and reuse (Palestine): Scale-up analysis based on the Marj Naje pilot indicates decentralised systems could provide ~2 million m^3/year of treated wastewater (approximately ~10% of current irrigation demand in the targeted rural areas), offering a politically resilient and circular non-conventional water source and reducing environmental and public health risks linked to cesspits.
- Circular organic resource management: Material flow analysis indicates that in Jordan the available organic residues and livestock excreta could fully cover N, P and K fertilisation needs, while in Palestine recycling potential could fully cover nitrogen and partially cover phosphorus and potassium, reducing reliance on imported fertilisers and strengthening circularity.
- Renewable energy integration: Solar deployment (29.7 kWp) at NARC's Deir Alla station demonstrated >11,000 JOD/year savings, improving the economic viability of water-saving and reuse measures under rising energy costs.

The analysis shows that the combined implementation of priority measures yields transformative system-level effects. In Jordan, rainwater harvesting, soil organic matter restoration and smart irrigation together can generate major water buffering and efficiency gains; in Palestine, the combination of rainwater harvesting, soil restoration, decentralised wastewater reuse and smart irrigation can reduce groundwater abstraction by more than 50%, slowing aquifer depletion and enhancing long-term resilience.

SWOT and strategic implications

The foresight-framed SWOT concludes that the ATS is structurally robust but implementation-sensitive. Its success depends less on technical validity than on enabling institutional, financial and socio-economic conditions. Key implications include: prioritising early visible wins, sequencing measures to balance short- and long-term goals, strengthening governance coordination and institutional learning, and embedding adaptive management into implementation pathways.

Operationalization of the ATS

1) Governance actions to operationalize the ATS

Because most measures ultimately require implementation by farmers, the ATS depends on governance arrangements that align institutions, incentives, capacities and monitoring systems around a shared transformation agenda. Priority governance actions include:

- **Political buy-in and institutional endorsement**: The ATS represents a shift away from prevailing "modern" agricultural policy and therefore requires formal recognition by key authorities, the identification of institutional champions, and integration into relevant national strategies and investment frameworks. In Jordan, the WEFE Nexus Committee provides an existing coordination structure that could adopt the EcoFuture Strategic Plan as a blueprint for WEFE operationalization.
- **Operational agencies and coordination mechanisms**: Implementation requires mapping measures to operational agencies, clarifying overlaps and mandate gaps, and reinforcing delivery capacity. Strengthening extension services and positioning research institutions is highlighted as critical for translation from evidence to farmer adoption.
- **Funding and financing as governance instruments**: Governance must link strategic priorities to funding pathways (public budgets, donor funding, development finance, private co-investment), including blended finance and incentive schemes for farmers to overcome adoption barriers.
- **Clearing house for results, monitoring and adaptive management**: Establish a national WEFE knowledge/data platform to consolidate pilot outcomes and monitoring data, define core indicators, and enable evidence-based scaling.
- **Training hubs as transition infrastructure**: Institutionalise training hubs, prioritising ATS-relevant topics and linking training to monitoring and knowledge systems.

Governance implementation must remain territory-sensitive: Jordan can build on stronger institutional capacity and focus on coordination, scaling and financing; Palestine requires prioritisation of decentralised solutions, community-based schemes and organisational models that function under access and infrastructure constraints.

2) Operationalisation actions for implementation-sensitive measures

While many measures are implementable through established pathways, four measure groups require significant preparatory work prior to scaling:

- **Rainwater harvesting for protected agriculture**: standardised technical specifications, representative pilots, farmer outreach, cost–benefit validation, and integration with soil restoration to maximise retention and system benefits.

- **Smart irrigation and reduced water use**: soil/land-use mapping, baseline data, distributed instrumentation, advisory and decision-support services, validation through modelling and satellite-based analysis, and hands-on farmer training to build trust and usability.
- **Organic matter recycling**: assessment of residue availability, establishment of collection/processing centres, quality standards for compost, business model development, and pilot applications tied to soil and yield monitoring.
- **Green water enhancement through soil organic matter addition**: baseline soil assessments, pilot implementation, training, and monitoring to quantify and communicate irrigation reduction and yield-stability benefits as the basis for scaling.

3) Enablers for systemic transition and sequencing

The foresight analysis emphasises that long-term success depends on system-level enablers that allow the ATS to scale and persist: evolving production models toward regenerative and resource-efficient systems; strengthening cooperatives and economies of scale; enabling new business models and service ecosystems; improving marketing, certification and territorial branding; and supporting diversification toward crops and products adapted to arid and semi-arid conditions.

To manage risk and adoption barriers, early, visible gains are required to build trust and momentum, while longer-term regenerative and diversification measures must be embedded through appropriate governance arrangements, financing mechanisms and market structures.

Priority actions

On this basis, the Strategic Plan defines a set of priority actions to guide implementation in the two territories.

Priority actions for Jordan

- **Endorse the ATS** as a guiding framework for WEFE nexus operationalization and policy alignment.
- **Prioritise demand-side water security measures**, including water loss reduction, smart irrigation, rainwater harvesting and soil-based water retention.
- **Align financing and incentives** with regenerative, water-efficient and circular agricultural practices.
- **Strengthen WEFE coordination and delivery capacity**, clarifying institutional roles and reinforcing extension services and research centres.
- **Scale training, demonstration and monitoring infrastructure**, establishing permanent learning hubs and data platforms for adaptive management.

Priority actions for Palestine

- **Focus on decentralised, community-based WEFE solutions** adapted to infrastructure and access constraints.
- **Scale decentralised wastewater treatment and reuse** to increase irrigation water availability and reduce pollution.
- **Promote regenerative, low-input farming systems** and strengthen cooperatives and local service providers.
- **Strengthen collective organisation and local service provision**, enabling cooperatives and civil-society actors to facilitate access to finance, training, technologies and markets.
- **Use the ATS to guide donor alignment**, ensuring coherent, WEFE-integrated interventions.

These actions will help operationalize the proposed paradigm, enabling the Jordan Valley to not only address desertification but to also serve as a regional model for integrated, climate-adaptive development.

Baseline Conditions

1. Baseline Conditions of the WEFE Nexus in the JV

This section provides a brief overview of the WEFE Nexus in the Jordanian and Palestinian sections of JV. It describes the present-day, baseline conditions of the WEFE Nexus which will be compared with other scenarios aiming at improving the WEFE Nexus and address/reverse the impacts of desertification as well as developing a program of measures that strategically will adapt and mitigate the impacts of climate change. Detailed description of the baseline conditions of the WEFE Nexus for the whole JV can be found in Deliverable 3.4 of the EcoFuture project.

The JV is a critical region where the interplay of water, energy, food, and ecosystem dynamics presents both challenges and opportunities for sustainable development and climate change mitigation and adaptation. The valley's unique geographical and climatic conditions have historically made it a focal point for agriculture, requiring intensive water management strategies to overcome its arid climate. Water scarcity in this region is acute, with sources such as the Jordan River and Yarmouk River and underground aquifers under increasing pressure from over-extraction and pollution, directly impacting agricultural productivity and food security. Energy is another critical component, heavily intertwined with water through the energy-intensive processes of water pumping, treatment, and distribution, as well as in agricultural operations and food processing. The food sector in the JV is highly dependent on the sustainable management of water and energy resources, with agriculture accounting for a significant portion of employment and food supply in the two territories yet facing the challenges of limited water availability and the need for energy-efficient technologies. The ecosystem of the JV, characterized by its rich biodiversity and unique habitats, plays a crucial role in supporting agricultural activities. However, these ecosystems are under threat from overuse of natural resources, habitat destruction, and climate change impacts, necessitating integrated approaches to management. The WEFE nexus emerges as a vital framework in this context, emphasizing the interconnectedness of these sectors and the need for a holistic management approach to achieve socioeconomic welfare for the people of the valley.

1.1 Water

The major water sources in the JV are Jordan River, Lake of Tiberias and Yarmouk and Zarqa rivers. Lake Tiberias is the largest surface freshwater reservoir in the region. The Lower part of the Jordan River originates from the Lake of Tiberias. Historically, the Lower Jordan River received around 600 MCM/yr from the Lake of Tiberias and about 470 MCM/yr from Yarmouk River. Additional inflow was from Zarqa River and nine major Jordanian streams entering the valley from east, resulting in an outflow of 1,250 MCM/yr into the Dead Sea. Due to water diversion projects the outflow has decreased to 40-100 MCM/yr (Royal HaskoningDHV and MASAR, 2015). The Yarmouk River is the main water source of the King Abdullah Canal (KAC), which carries water for irrigating crops in the JV and for domestic use in Amman. Moreover, water from Yarmouk River is diverted by dams, including the Wehdah dam (or Unity Dam) which is located at the border with Syria. The KAC has a total length of 110 km and receives water from Lake Tiberias and a discharge from King Talal Dam (KTD), which is a mix of freshwater from the Zarqa River and effluent from the As Samra wastewater treatment plant (WWTP).

Drinking water in the Jordanian part of the JV is provided by groundwater (GW) resources. The total supply of drinking water for the Jordanian part of the JV is 23.5 MCM/yr while the demand is 26.0 MCM/yr (Table 1). The supply of irrigation water in Jordan is 206 MCM/yr while the demand 400 MCM/yr. For the Palestinian part of the JV, Mekorot, the Israel Water Company supplies water which is mixed with water from wells, and it is used for domestic consumption (6.4 MCM/yr). Lastly, groundwater (48.1 MCM/yr), harvested rainwater (2.7 MCM/yr) and treated wastewater (0.7 MCM/yr) are used for irrigation purposes in Palestine (51.5 MCM/yr). The demand for drinking water is 10.0 MCM/yr and the demand for irrigation water is 182.0 MCM/yr (Table 1). Both territories exhibit significant deficit in the water supply and demand that will increase due to climate change and the expected population growth.

Table 1. Supply and demand for drinking and agricultural water and water deficit.

Drinking water (MCM)	Supply	Demand	Deficit
Jordan	23.48	26.00	-2.52
Palestine	6.40	10.00	-3.60
Agricultural water (MCM)			
Jordan	206.00	400.00	-194.0
Palestine	51.50	182.00	-130.5

Figure 1 presents the vulnerabilities in terms of water security due to climate change in the Jordanian and Palestinian part of the JV. In general, the decrease in groundwater recharge due to the lack of precipitation, accompanied by high temperatures, can lead to high salinity levels which result in water quality deterioration and the need for desalination. Moreover, reduced precipitation amounts will result in less surface runoff which will provide less water for irrigated agriculture. In addition, extreme weather events such as floods change the distribution of precipitable water during the year and thus reduce the amount of water available for agriculture. To conclude, water security in the Jordanian and Palestinian part of the JV is very vulnerable since they rely mostly on local surface and ground water sources and in the case of Jordan on WWTP reuse.

For the Jordanian part of the JV, the Ministry of Water and Irrigation (MWI, 2014) estimates that 50% of the water is lost due to leakage in the drinking water network, attributed to inadequate maintenance. For the Palestinian part of the JV, losses in the drinking water supply network are in excess of 40-50% of the supply. Table 2 presents the irrigation rate, and the drinking water use per capita for the two territories. The irrigation rate for Jordan was estimated to be 621.6 mm/dunum and for Palestine 565.9 mm/dunum. The drinking water use per capita has been estimated to be 248 L/d/cap for Jordan and 205 L/d/cap for Palestine. By accounting for the water losses in the distribution network in Jordan and Palestine, only half of this water is reaching the consumers.

Table 2. Irrigation rate and drinking water use per capita for the Jordanian and Palestinian part of the JV.

	Units	Jordan	Palestine
Agricultural Area	km2	348.9	173
Irrigated agricultural area	km2	331.4	91
Irrigation water	MCM/yr	206.0	51.5
Irrigation Rate	mm/dunum	621.6	565.9
Drinking water	MCM/yr	23.5	6.4
Population	cap	260,000	70,000
Water use per capita	L/d/cap	248	205

The water quality in the JV has undergone significant changes over time, primarily due to over-extraction, pollution from runoff, and wastewater discharge. Surface water in the Jordan River has seen increased salinity levels. Similarly, groundwater quality has been affected by overuse, leading to lowering of water tables and the intrusion of saline water in some areas, which complicates its use for drinking and agriculture without adequate treatment (WHO, 2017; FAO, 2017). Irrigation with highly saline water can cause soil salinization and can affect plant growth and yield, nutrient availability and soil properties (Sheferia et al., 2021).

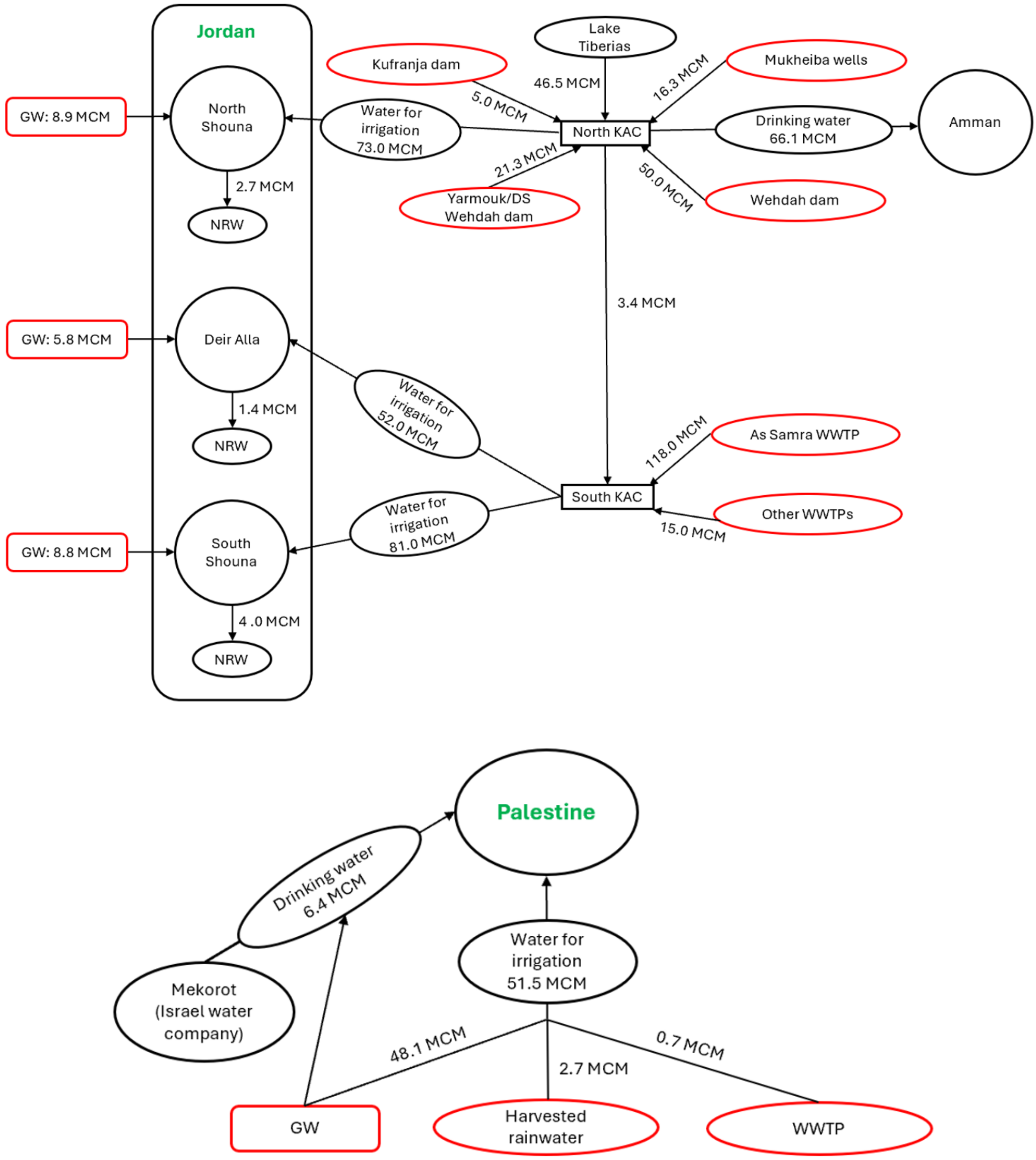


Figure 1. Vulnerabilities (red) in water allocation due to climate change in the two territories of JV (green). Abbreviations and units: All amounts are in MCM/yr. MCM, Million Cubic Meters per year; GW, groundwater; WWTP, Wastewater Treatment Plant; NRW, Non-Revenue Water; KAC, King Abdullah Canal.

1.2 Energy

Table 3 presents the energy supply and demand for the Jordanian and the Palestinian part of the JV. Country wide energy supply data were used to estimate the JV component based on the population ratio. For Palestine, the total electricity supply is 5,925.5 GWh (PCBS, 2019), supplied 93.4% by Israel, 4.4% by the Gaza Electrical Company and the remaining by Jordan and Egypt. It was assumed that the population in the JV is about 5% of the total and the electricity supply was calculated to be about 300 GWh. Similarly, the electricity supply in the Jordanian part of the JV based on population is 5% of the total energy consumption (23,654 GWh) which is 1,183 GWh. It appears that the supply in the two territories is meeting the current demand. However, the annual electricity demand in the two countries is increasing at a very fast pace necessitating strategies that will accomplish sufficient increases in energy supply that will cover the future demand.

Table 3. Energy supply and demand in the three territories of JV.

Energy (GWh/yr)	Jordan	Palestine
Supply	1,183	300
Demand	1,183	300

Electrical energy is supplied to customers via their national grids. Heat and power customers may use natural gas distributed by pipes or fuel supplied mainly by ground transportation and marginally by pipes.

The Jordanian national interconnected grid transmits electricity from the power stations to the distribution substations and transformer substations in the JV via 400-kV and 132-kV power lines. The grid has a clearly identifiable north-south axis. The national 400-kV power line runs outside the JV from Aqaba via Amman and up to the Syrian border. In the north, the power grid is connected to the Syrian grid through a 230-kV and a 400-kV power line. In the south, there is a 400-kV connection to the Egyptian grid. The interconnected grid feeds the local distribution systems that serve most of Jordan's population, including that in the JV (Kool, 2016).

Palestine is heavily dependent on Israel for meeting its energy requirements. Almost all petroleum products and most of the electricity are imported from Israel and the possibility of diversifying the energy development and imports from other countries is currently limited due to political constraints as Israel controls area C (60% of the West Bank). According to the Palestinian Central Bureau of Statistics (PCBS), Palestine's total electrical energy consumption in 2019 was reported to be 5,929.5 GWh. This quantity is almost entirely imported from outside sources, mainly from the IEC. While a share of 5% of the total electricity supply was imported from Jordan and Egypt, the largest electricity supplier was the IEC.

The current situation is that, in the JV, the two territories can provide satisfactory energy supply and demand services by mainly non-renewable sources. However, JV can be a great source of renewable energy, far more than the local JV demand.

1.3 Food

1.3.1 Food status baseline

The agricultural land in the JV (Jordanian and Palestinian sections) covers 62,483 ha and accounts for 28 % of the total area. The distribution of agricultural land in the two territories is 51.7 % for Jordan and 19.8 % for Palestine. Regarding aquaculture, the Jordanian territory uses 73 ha and the Palestinian 30 ha (Table 4).

The area designated as uncultivated land or nature reserves is 81,029 ha for Jordan and 67,130 ha for Palestine. The built-up area, which includes residential, commercial, and industrial zones, is currently 4,462 ha for Jordan and 2,530 for Palestine. The water reservoirs which are essential for water storage and management in the valley, cover 555 ha in Jordan and 26 ha in Palestine.

Table 4. Land use of the two territories of JV.

Land use (ha)	Jordan	Palestine
Agriculture	45,183	17,300
Built Area	4,462	2,530
Fish farming	73	30
Natural/Uncultivated	81,029	67,130
Reservoirs	555	26
Wadis	2,416	1,380
GRAND TOTAL	133,718	88,396

Jordanian part of the JV: The agricultural production and crop pattern reflect a combination of environmental challenges and evolving agricultural practices. Recent years have seen a decline in vegetable production. This drop is attributed to various factors including rising production and labor costs, the soaring cost of inputs like fertilizers and pesticides, and challenges related to irrigation and water availability. The region has also been affected by unstable weather conditions, which have led to successive losses for farmers. Furthermore, external factors such as regional market dynamics have impacted the export potential of the valley's production. Date palm cultivation in the JV has seen significant growth and development over the last years. This shift in agricultural focus is driven by the climatic suitability of the region for date palms, the high market value of dates and the challenges faced in traditional vegetable farming.

Animal production in the JV has evolved significantly over the years, reflecting changes in agricultural practices and adaptation to environmental conditions. The valley, known as the Ghor, offers a year-round agricultural climate and a reliable water supply, which has made it a key area for agriculture, including animal farming. In the past two decades, there has been a noticeable shift in dairy farming. Farmers have largely transitioned from local cow breeds to international cattle due to their higher productivity. The local Baladi cows, which are well-adapted to the harsh environment, have seen a decrease in numbers. Small-scale farming often involves an interdependency between crop and livestock production, with farmers utilizing a portion of their land for dairy farming and the rest for crop production. The dairy industry in Jordan has also seen growth, with the per capita consumption of dairy products reaching 78 kg. Most milk produced is delivered to dairy factories, which process it into various products, including yogurt, labaneh, cheese, and ghee.

The JV's animal production is also influenced by its history as a migratory route for animals and birds, which has contributed to the biodiversity of the region. Today, the valley continues to play a role in animal migration, including significant bird populations that rely on the valley during their migratory seasons. Overall, the animal production in the JV is characterized by a mix of traditional practices and modern developments, with an increasing focus on sustainability and efficiency in the face of environmental and economic challenges.

Fish production in the JV has emerged as a vital sector for local economic development, job creation, and food security. The region has seen significant efforts to establish aquaculture and aquaponics systems that are both sustainable and efficient. Aquaculture in the JV has been largely dominated by the private sector. The most farmed fish in the valley are tilapia and the common carp due to their profitability and reproductive capabilities. As of 2018, fish farms in Jordan produced approximately 1,300 tonnes of fish, substantially more than the output from maritime fishing, which was 264 tonnes for the same period.

Jordan is highly dependent on food imports due to its water scarcity, with agriculture consuming a substantial portion of Jordan's water resources yet only contributing to a small fraction of the Gross Domestic Product (GDP). The country imports up to 98% of its consumable items, including staples such as wheat, barley, sugar, rice, powdered milk, tea, coffee, corn, vegetable oil, cheese, chickpeas, vermicelli, and lentils. Imports have increased to meet the demands of a population that has nearly doubled in the past decade. On the export side, Jordan has seen an increase in agricultural exports, including horticultural products, poultry, and small-scale herding. Jordan's import and export patterns in food production exhibit strengths in its ability to produce a variety of fruits and vegetables in the JV, supported by infrastructure. However, the dependence on food imports due to water scarcity and the economic limitations of expanding agricultural land are challenging.

Palestinian part of the JV: The total agricultural area is 5505.3 ha (as of 2021). Permanent (tree) crops accounted for 2930 ha (53.2% of land area), while vegetables and field crop cultivation accounted for 2085 ha (37.9%). The total area of land cultivated (as of 2021) was 5278 ha. 2204 ha were cultivated with field crops (41.8%) while tree crop area was 2910 ha (55.1%). 163 ha (3.1%) were cultivated with field crops of which 96.5 ha were harvested that year. For the field crop area, the rainfed crops comprised 56 ha (34.4% of field crops) while 107 ha were irrigated (65.6%).

Official data indicate a significant decline in the agricultural sector's contribution to the economy of the Palestinian Territory over the past few decades. In 1967, agriculture contributed about 53% of the total GDP. By 2016, this figure had dropped to approximately 2.8% in the West Bank and 4% in the Gaza Strip (UNSCO, 2016). However, these figures can be misleading, as they suggest that agriculture's economic importance is now minimal. They fail to account for informal agricultural activities and do not include agricultural industries like dairy processing, olive oil production, and cucumber pickling. Additionally, agricultural activities on plots smaller than 1,000 m² and part-time farming are not included. Despite the dramatic reduction in GDP contribution, the agricultural sector remains crucial to the economy.

According to an FAO report in 2021, the structure of production in the agriculture sector of Palestine in 2019 comprised as follows: approximately 50% comes from livestock products, including meat from chickens (22%), sheep (5%), goats (3%), and cattle (1%); milk from cows (4%), sheep (4%), and goats (1%); and eggs (4%). Notable shares also come from olives (13%), tomatoes (8%), cucumbers and gherkins (5%), grapes (4%), and almonds (3%), along with other fruits and vegetables.

The livestock sector accounts for approximately 45% of the total agricultural value in the Palestinian Territory (FAO, 2021). Over the past decade, the poultry industry has seen notable growth, with the number of birds being more than doubled between 2010 and 2021 (PCBS, 2022). Apiculture has also seen remarkable expansion, with the number of beehives increasing by 68% between 2010 and 2021 (PCBS, 2022). Dairy farms are expanding as well, although they have not reached the same level of mechanization as poultry farms.

Population growth and rapid urbanization have increased the pressure on the agriculture sector. The growing gap between local production and consumption has made imports increasingly essential to meet food needs. While the Occupied Palestinian Territory is largely self-sufficient in vegetables, grapes, figs, olive oil, poultry, meat, eggs, and honey, it remains highly food insecure at the national level. The territory relies on imports for 40% of its main food items and more than 95% of its cereals and pulses.

1.3.2 Soil salinity and its impact on crop productivity

Climate change and several biotic and abiotic stresses challenge the growth and production of agricultural crops. Among abiotic stresses, soil salinity is considered as one of the leading limiting factors responsible for growth and production decline of agricultural crops (Majeed and Muhammad, 2019). Globally, more than 1 billion hectares of land are already salt-affected, posing a serious threat to sustainable food production (FAO, 2024).

Soil salinity induced by climate change refers to a significant increase in the concentration of soluble salts in the soil column caused by various climate change aspects including increasing air temperature, changing rainfall patterns, rising sea level, and accelerating droughts (Haj-Amor et al., 2022). The accumulation of water-soluble salts in the plant rooting zone, thereby impacting water and soil quality, and inhibiting plant growth. Osmotic changes in soil water caused by total salinity reduce the ability of plants to take up water from the soil. In addition, specific ions such as Na and Cl negatively impact plant physiology and become toxic when absorbed by the plant at higher than beneficial amounts. In addition, saline soils can reduce plant nutrient uptake or cause ion imbalances (Hopmans et al., 2021).

The overuse and misuse of fertilizers can contribute to significant soil salinity buildup. Shifts in the soil microbial community in response to salinity stress could have implications for carbon cycling. Salinity also affects microbial diversity and richness directly and/or indirectly by changing soil edaphic characteristics. Lastly, soil salinity can cause a decrease in soil organic carbon (SOC) content.

In general, in very low salinity levels, the crop yield remains unaffected, whereas moderate and high salinity levels (EC= 4 dS m-1) may affect crops growth. Many studies have found out that soil salinity can induce significant crop yield reduction ranging from 13.3 to 58.3% (Haj-Amor et al., 2022).

Sustainability of irrigated agriculture in the JV, particularly in the central and southern regions, is threatened by progressively increasing soil salinity. The progressive increase in soil salinity in the JV is attributed to unsustainable agricultural practices and inputs, quality of irrigation water, lack of advanced irrigation technologies and efficient drainage systems, and improper land management.

Agricultural operations in the JV are characterized by intensive open field, low tunnel, and greenhouse production with animal manure input of 10-20 t ha−1 year−1 and chemical fertilizer input (N, P, K) exceeding 3-7 t/ha/yr; some with high salt indices. The mismanagement of fertilizers contributed to the current unfavourable status of salinization (Ammari et al., 2013).

1.3.3 Potential nutrient supply and demand

The potential C, N, P, K supply and demand of the two territories of the JV was estimated using the Bio-residue/Excreta calculator (Bio-REX). Bio-REX calculates the potential fertilizer demand and the biomass nutrient fluxes from the following sources: livestock excreta/manure, biosolids from wastewater treatment plants, composting of the organic fraction of municipal solid wastes and olive mill waste water (Nikolaidis, 2011). For the Jordanian part of the JV, recycling of biomass covers the N, P and K fertilization needs. More specifically, the N demand is 3,629 ton N/yr and the potential N supply is estimated at 26,013 t N/yr. Moreover, the P demand is 3,629 ton P/yr and the potential P supply is estimated at 7,208 ton P/yr. Lastly, the K demand is 3,629 ton K/yr and the potential K supply is estimated at 12,252 ton K/yr. While for the Palestinian part of the JV, recycling of biomass covers the N fertilization needs as the N demand is 2,090 ton N/yr and the potential N supply estimated at 3,699 ton N/yr. On the contrary, recycling of biomass doesn't cover the P and K fertilization needs. More specifically, it falls short by 34% of the P needs (P demand: 1,447 ton P/yr and potential P supply: 954 ton P/yr) and 29% of the K needs (K demand: 2,573 ton K/yr and potential K supply: 1,828 ton K/yr). Fertilizer demand in Palestine can be satisfied by the recycling of compost and livestock excreta.

1.4 Ecosystem

The JV (JV) is a vital and diverse environment, encompassing various ecosystems, including freshwater, shrublands, drylands, agricultural and urban ecosystems in a sub-tropical climate. It serves as the biological heart of the Middle East, supporting its unique flora and fauna, and acting as an important migratory pathway for birds travelling between Africa and Europe. The JV is characterized by a wide range of bio-climatological and physical conditions supporting all human activity, vegetation, and wildlife (Kool, 2016).

The JV stands as a vital repository of freshwater ecosystems, prominently exemplified by the winding course of the Jordan River and its tributaries. These freshwater habitats play a pivotal role in sustaining the region's biodiversity, offering a sanctuary for numerous plant and animal species uniquely adapted to the aquatic environment. These freshwater ecosystems are critical breeding grounds for various aquatic species, fostering biodiversity and supporting the delicate balance of the entire ecosystem. Endemic species, such as the indigenous fish populations and migratory birds, rely on these habitats for their survival. In addition to the Jordan River, several other freshwater ecosystems within the JV contribute to its high biodiversity. Seasonal streams and wetlands, often fed by runoff from the surrounding hills, provide dynamic environments that host a variety of flora and fauna.

The main drivers that affect the system in the area are climate change, population growth, land use change and pollution. The environmental pressures exerted in the JV are the result of intensive agricultural activities (agriculture, livestock and aquaculture), tourism, climate change, geogenic pollution, population, migration and invasive species. These pressures have resulted in significant impacts to the WEFE Nexus with surface water flow decline, groundwater depletion, high groundwater salinity, pollution and loss of biodiversity.

Climate change, following the more general Mediterranean trend of water resources shortages, has been projected as a serious threat to the area. The region's climate is changing, with the potential for increased droughts, higher temperatures and more extreme weather events, posing significant challenges to the preservation of ecosystem. Climatically, the JV is characterized by hot dry summers and mild wet winters, becoming progressively drier moving southward through the valley towards the Dead Sea. It is predicted that the Eastern Mediterranean will continue to face a reduction in annual precipitation, longer hot summer dry season, and shorter cool wet winter season due to climate change (Hochman et al., 2018).

Population growth is affected significantly by the political instability in the region that is fueling refugee movements into the area and causing additional pressure on water, energy and food resources.

Land use distribution has been stabilized in the region to a large extent. It is not expected to have increases in the cultivated areas in Jordan and Palestine. On the other hand, further intensification of agriculture in Jordan and Palestine is expected, especially if more water becomes available in Palestine for irrigation.

The main sources of 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. In addition to the above, the impact to water quality due to saline bedrock, which increases the chloride concentration in the irrigation water, all provide a complete picture of the anthropogenic and geogenic pollution in water and soil (Royal HaskoningDHV and MASAR, 2015; Kool, 2016).

The Dead Sea, a critical component of the JV ecosystem, faces severe threats due to declining surface water flow, particularly from the Jordan River. Extensive water withdrawals upstream, especially above the Sea of Galilee, for agriculture, domestic, and industrial uses have dramatically decreased the water reaching the Dead Sea, leading to a rapid decline in its water levels (Ghazleh et al., 2011; Oroud, 2023). This decline has exposed large areas of the Sea's bed, disrupted its unique saline ecosystem, caused dangerous sinkholes, and posed risks to surrounding infrastructure. The shrinking sea also threatens the tourism industry, vital for local economies, and challenges mineral extraction operations. Apart from the surface water flow declines, a dramatic groundwater level decline has been observed due to over abstraction (approximately 3 times the amount of recharge). Recent studies have shown that this extreme overexploitation has led to average groundwater level declines of up to 10 m/yr in some areas and 4-5 m/yr in most well-field areas (Al Absi et al., 2020). The surface and groundwater flow declines are described in detail in the "Water" section.

Point sources such as WWTPs and industries, and non-point sources including fertilizer, pesticide and herbicide pollution from agriculture and livestock farming have impacted on the water quality of surface and groundwater resources. In the Jordanian part of the JV, there are 6 operating WWTPs (Al-Baqaa, As-Salt, As-Samra, Fuheis, Kufranja and Wadi Al Seer). On the contrary, in the Palestinian part of the JV, the wastewater treatment levels are extremely low. Wastewater collection and treatment was neglected since higher priority is given to securing a safe water supply and protecting reliable resources for domestic use. All the Palestinian communities lack wastewater collection networks and rely on cesspits for the disposal of wastewater, except for Jericho (Kool, 2016). Regarding the industries, in the Jordanian part of the JV, there are industries related to agriculture (industries supplying greenhouses, on-farm water management equipment and agricultural inputs), construction (quarries), metal and food processing, crafts and handicrafts processing minor agricultural products like grains, olives and dates (Kool, 2016). In the Palestinian part of the JV, there are industries related to agriculture (crop production and livestock farming), tourism (religious and archaeological sites), food processing and packaging (olive oil production, packaging of fruits and vegetables), handicrafts and artisanal goods (pottery, woven goods, embroidery), construction materials (extraction of stones and gravel) and renewable energy initiatives (small solar energy projects).

Non-point sources include agricultural return flows polluted with phosphates, salt, nitrates, pesticides, herbicides and chemical fertilizers, and animal husbandry which generates pollution sources in terms of manure (solid and fluid) and animal carcasses, which are potential threats for the environmental and public health (Kool, 2016). Ammari et al. (2013) present the type and amounts of fertilizers used in JV in 2008 and 2009. Farmers in the JV commonly use a balanced NPK fertilizer with a 20-20-20 ratio, applying it at rates of 80-80-80 kg per hectare for nitrogen (N), phosphorus (P) and potassium (K) (Mashatleh et al., 2024).

The presence of saline bedrock often leads to the development of saline groundwater, affecting both the quality and availability of water resources (Hötzl et al., 2009). In conjunction with saline bedrock, the surrounding soil may also become saline (Richards, 1954). Soil degradation resulting from salinity is a major environmental constraint with severe adverse impacts on soil productivity, agricultural sustainability and food security (Ammari et al., 2013). Soil salinization can negatively impact plant growth and soil fertility (Sheferia et al., 2021). More specifically, Ammari et al. (2013) found out that in the southern and central regions of the valley (81% and 75% of top-soils were saline, respectively) compared to the northern JV where only 37.5% of soils were saline. Results showed that 17.5% and 28.6% (46.1% in total) of saline top-soils in the northern and southern JV, respectively, were strongly saline, whereas 35% of saline soils in the central JV were moderately saline. In sub-soils of the three regions of the valley, the majority of saline soils were moderately saline.

Highly Saline and Sodic water qualities can cause problems for irrigation, depending on the type and amount of salts present, the soil type being irrigated, the specific plant species and growth stage, and the amount of water that is able to pass through the root zone (Sheferia et al., 2021). The combined effects of saline bedrock and saline soil can disturb local ecosystems.

1.5 Summary of the current situation of the WEFE Nexus

The current situation of the WEFE Nexus in the JV can be summarized as follows:

Water:

- Both territories exhibit significant deficit in the water supply and demand that will increase due to climate change and the expected population growth.
- For both territories, 50% of the water is lost due to leakage in the drinking water network, attributed to inadequate maintenance.
- Water reuse is only 1% of the total irrigated water in the Palestinian section of the JV and it has therefore the potential to increase substantially, providing a source of water and reducing the deficit.
- Water security in the Jordanian and Palestinian part of the JV is very vulnerable since they rely mostly on local surface and ground water sources and in the case of Jordan on WWTP reuse.

Energy:

- The supply of energy in the two territories is meeting the current demand. However, the annual increase in electricity demand in the two countries is increasing at a very fast pace necessitating strategies that will accomplish sufficient increases in energy supply that will cover the future demand.
- Palestine is heavily dependent on Israel for meeting its energy requirements. Almost all petroleum products and most of the electricity are imported from Israel and the possibility of diversifying the energy development and imports from other countries is currently limited due to political constraints as Israel controls 60% of the West Bank.
- JV can be a great source of renewable energy, far more than the local JV demand.

Food:

- The JV is the food basket of Jordan and Palestine where most of the food production is taking place.
- Serious issues have been identified in the food sector that need to be addressed. The agricultural land has been degraded due to continuous cultivation for millennia which has as a result extremely low soil organic carbon. The impact of this situation is depicted in the estimated crop yields. This is a common problem necessitating measures for soil restoration using agroecological practices and active carbon additions to soils that will improve soil quality, fertility and health.
- Climate change and several biotic and abiotic stresses challenge the growth and production of agricultural crops. Among abiotic stresses, soil salinity is considered as one of the leading limiting factors responsible for growth and production decline of agricultural crops. The progressively increasing soil salinity threatens the sustainability of irrigated agriculture in the central and southern regions of the JV. This increase is attributed to unsustainable agricultural practices and inputs, quality of irrigation water, lack of advanced irrigation technologies and efficient drainage systems, and improper land management.

- Population growth and rapid urbanization have increased the pressure on the agriculture sector. The growing gap between local production and consumption has made imports increasingly essential to meet food needs.

Environment:

- The JV is a vital and diverse environment, encompassing various ecosystems, including freshwater, shrublands, drylands, agricultural and urban ecosystems in a sub-tropical climate. It serves as the biological heart of the Middle East, supporting its unique flora and fauna, and acting as an important migratory pathway for birds travelling between Africa and Europe.
- The main drivers that affect the system in the area are climate change, population growth, land use change and pollution. The environmental pressures exerted in the JV are the result of intensive agricultural activities (agriculture, livestock and aquaculture), tourism, climate change, geogenic pollution, population, migration and invasive species. These pressures have resulted in significant impacts to the WEFE Nexus with surface water flow decline, groundwater depletion, high groundwater salinity, pollution and loss of biodiversity.
- Significant surface and groundwater flow declines have been observed in the Jordan River and the discharge to the Dead Sea has been decreasing dramatically leading to the water level declines over the years.
- The main sources of 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.
- Climate change has been projected as a serious threat to the area. The region's climate is changing, with the potential for increased droughts, higher temperatures and more extreme weather events, posing significant challenges to the preservation of ecosystem.

Vision

2. Vision

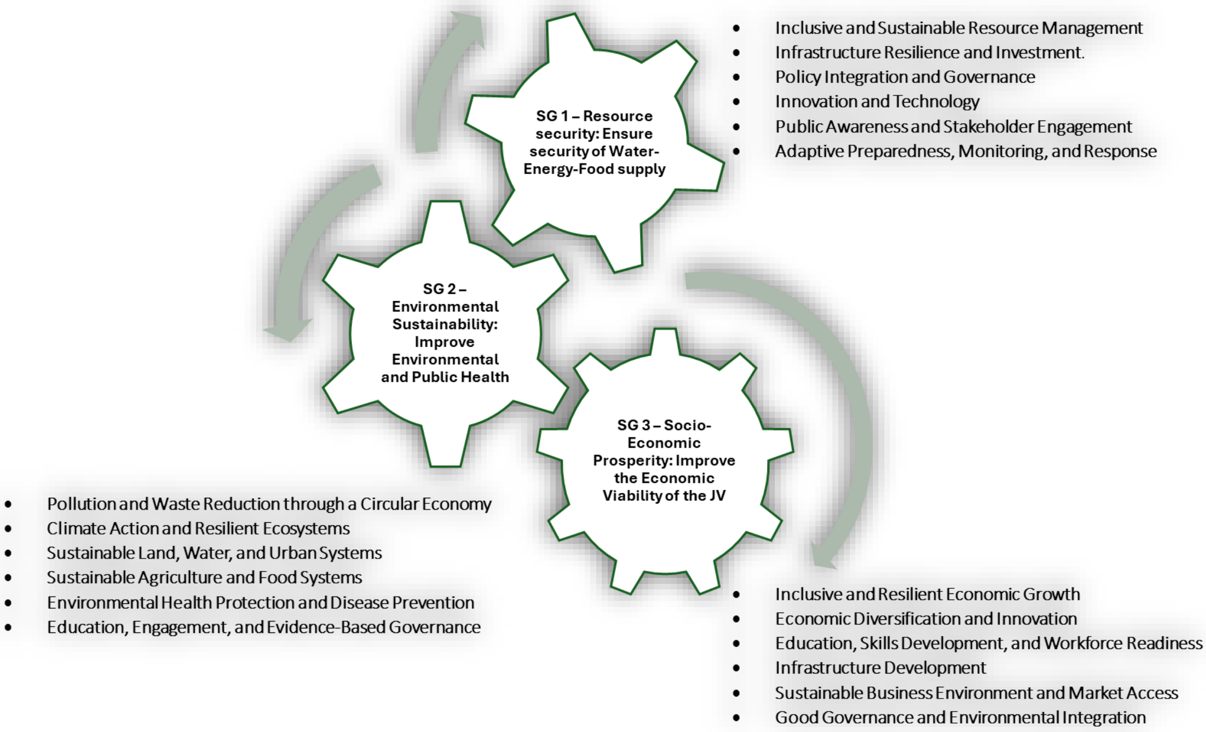
The ecosystem of the JV, characterized by its rich biodiversity and unique habitats, plays a crucial role in supporting agricultural activities. The JV faces increasing challenges from desertification, a process that degrades fertile land into desert through both natural forces and human activities. This degradation threatens vital ecosystems, agricultural productivity, and the livelihoods of communities across the region. Natural factors such as drought and climate-induced flash floods weaken soil and vegetation, while unsustainable land use practices accelerate soil deterioration. Addressing these complex challenges requires integrated solutions. The WEFE nexus emerges as a vital framework in this context, emphasizing the interconnectedness of these sectors and the need for a holistic management approach to achieve socioeconomic welfare for the people of the valley. The EcoFuture project responds by applying the WEFE nexus approach, aiming to build resilience, promote sustainable resource management, and improve socio-economic conditions for people living in the JV. The objective of this strategic plan is to define a program of measures that will enable the region to strategically adapt to and mitigate the impacts of climate change, enhance the WEFE Nexus and reverse the effects of desertification. This Strategic Plan is common for both the Jordanian and the Palestinian territories of the JV since the stakeholders in the region share common challenges, barriers and potential solutions to address desertification.

The overall project objective of the EcoFuture project is to develop a climate-change adaptation program to combat desertification oriented towards improving socio-economic welfare for people in the JV and it will be based on WEFE nexus methodologies.

The partners of the EcoFuture project **envision the Jordan Valley as a region where WEFE resource integration ensures resource security, enhances environmental and public health, and maximizes socio-economic prosperity for its people.**

Strategic Goals

3. Strategic Goals (SGs)



SG 1 – Resource security: Ensure security of Water-Energy-Food supply

To ensure the security of water, energy, and food supply in the face of growing climate, environmental, and socio-political pressures, a strategic plan must adopt integrated, sustainable, and resilient approaches across all levels of governance and society. The following 6 key objectives outline the core pillars of such a strategic plan:

- **Inclusive and Sustainable Resource Management.** Promoting the efficient, equitable, and diversified use of water, energy, and land is foundational to long-term resource security. This involves advancing conservation practices, minimizing waste, and protecting critical ecosystems such as watersheds and soils that support resource availability. It also includes diversifying supply sources—such as desalination, rainwater harvesting, renewable energy, and resilient food systems—to reduce vulnerability to disruptions. Equally essential is ensuring fair access for all population groups, particularly marginalized and vulnerable communities, by addressing affordability, geographic disparities, and systemic inequalities. These efforts must be integrated to create a resource base that is both sustainable and inclusive across all sectors and communities.
- **Infrastructure Resilience and Investment**. Modernizing and upgrading vulnerable or aging infrastructure is crucial to sustaining reliable supply systems. This includes investment in decentralized and renewable energy solutions, as well as the expansion of water storage, treatment, and reuse infrastructure. Building infrastructure that is resilient to climate shocks and future demand increases should be prioritized.
- **Policy Integration and Governance.** Effective governance requires breaking down silos and fostering cross-sectoral collaboration among national ministries, regional authorities, and stakeholders. Regulatory frameworks should be structured to incentivize sustainable and equitable resource use.
- **Innovation and Technology**. Supporting innovation in areas such as smart agriculture, precision irrigation, and clean energy is vital to driving efficiency and sustainability. Advanced

data analytics, remote sensing, and digital platforms can be leveraged for real-time monitoring and informed decision-making. Adoption of climate-smart technologies should be encouraged at all scales.

- **Public Awareness and Stakeholder Engagement**. Engaging communities and stakeholders in resource management fosters ownership, accountability, and resilience. Public education initiatives can promote awareness of conservation practices, while inclusive decision-making processes ensure that planning reflects the needs and knowledge of affected populations.
- **Adaptive Preparedness, Monitoring, and Response**. Building resilience to resource-related disruptions requires integrated systems for both emergency preparedness and continuous adaptation. This includes developing contingency plans for crises such as droughts, energy shortages, and food insecurity, alongside strengthening early warning systems and institutional coordination for rapid response. Equally important are robust mechanisms for monitoring progress, evaluating outcomes, and adapting strategies based on changing conditions. Setting measurable targets, using data-driven insights, and institutionalizing regular reviews will ensure that preparedness efforts remain responsive, effective, and aligned with long-term sustainability goals.

SG 2 –Environmental Sustainability: Improve Environmental and Public Health

To achieve environmental sustainability and improve environmental and public health, a strategic plan should include objectives that focus on reducing environmental degradation, protecting ecosystems, and minimizing health risks from pollution and climate change. The following 6 objectives outline the key pillars of such a strategic plan focused on environmental protection and health resilience:

- **Pollution and Waste Reduction through a Circular Economy.** Reducing pollution and transitioning to a circular economy are foundational to environmental and public health. Efforts must target cleaner air, water, and soil by reducing emissions, improving wastewater treatment, and minimizing chemical inputs. Simultaneously, waste reduction through reuse, recycling, and responsible disposal—especially of hazardous and electronic waste—should be prioritized. Circular business models and regulatory incentives can close material loops and reduce the environmental burden of consumption.
- **Climate Action and Resilient Ecosystems.** A dual focus on climate change mitigation and adaptation is essential. This includes reducing greenhouse gas emissions via renewable energy, energy efficiency, and sustainable transport, while enhancing natural carbon sinks like forests and soils. Protecting and restoring ecosystems, including wetlands, forests, etc. builds resilience against climate shocks and supports biodiversity, which is critical to both environmental stability and public well-being.
- **Sustainable Land, Water, and Urban Systems.** Integrating sustainability into land use, water management, and urban planning ensure balanced development and ecosystem protection. This includes nature-based solutions (NBS) for watershed and aquifer protection, efficient irrigation, and green urban infrastructure.
- **Sustainable Agriculture and Food Systems**. Agricultural practices must be transformed to reduce their environmental footprint. This includes encouraging organic and low-input farming, minimizing the use of harmful pesticides and synthetic fertilizers, and promoting agroecological methods. Strengthening local food systems and reducing food waste across the supply chain contribute to environmental sustainability and food security.
- **Environmental Health Protection and Disease Prevention.** Safeguarding public health requires active monitoring and mitigation of environmental risks. This includes tracking pollutants such as particulate matter and microplastics, addressing health impacts of climate change, and preparing health systems for emerging environmental threats. Early detection and integrated response planning can reduce the burden of climate- and pollution-related diseases.

- **Education, Engagement, and Evidence-Based Governance**. Community engagement and public education are key to building resilient, sustainable societies. Environmental awareness campaigns, citizen science, and participatory planning foster stewardship and accountability. Strong data systems, regular monitoring of environmental health indicators, and policy integration across sectors ensure adaptive, evidence-based decision-making and long-term progress.

SG 3 – Socio-Economic Prosperity: Improve the Economic Viability of the JV

To promote socio-economic prosperity and improve economic viability, a strategic plan should focus on inclusive, resilient, and sustainable economic growth. The following 6 objectives define a roadmap to foster long-term prosperity and socio-economic stability.

- **Inclusive and Resilient Economic Growth.** Fostering broad-based economic growth requires targeted job creation across agriculture, services, tourism, and emerging sectors, with a focus on empowering youth, women, and marginalized communities. Supporting SMEs through finance, capacity-building, and market access is essential to stimulate local entrepreneurship and reduce poverty. Social protection systems must be strengthened to build resilience against economic shocks
- **Economic Diversification and Innovation**. Reducing dependence on traditional sectors by expanding into agro-industry, eco-tourism, digital services, and sustainable manufacturing will enhance regional resilience and competitiveness. Encouraging entrepreneurship, supporting innovation ecosystems, and investing in research and development, particularly in climate-smart technologies, will unlock new economic opportunities and attract investment.
- **Education, Skills Development, and Workforce Readiness**. The JV needs a workforce that is equipped for future challenges. Strengthening vocational and technical training, particularly in agriculture, water management, and digital skills, will ensure alignment with labor market needs. Expanding STEM education and supporting lifelong learning and upskilling programs will prepare residents for new economic opportunities and enhance employability.
- **Infrastructure Development**. Modern, climate-resilient infrastructure is a backbone of economic viability. Strategic investments in transportation, renewable energy, water systems, and digital connectivity will lower logistical costs, integrate rural areas into value chains, and support trade. Infrastructure planning must prioritize underserved regions and anticipate future climate and population pressures.
- **Sustainable Business Environment and Market Access.** Creating an enabling environment for private investment and local enterprise growth requires simplifying regulations, ensuring legal clarity, and promoting ethical business conduct. Expanding trade logistics, certification systems, and access to regional and international markets, particularly for agricultural and locally produced goods, will improve competitiveness and increase incomes.
- **Good Governance and Environmental Integration.** Transparent, accountable institutions are critical for inclusive development. Strengthening local governance, improving service delivery, and promoting participatory planning will align public investment with community needs. At the same time, integrating environmental sustainability into economic planning—through green jobs, circular economy initiatives, and climate-smart agriculture, ensures long-term viability and resilience.

Program of Measures

4. Program of Measures to address desertification in the Jordanian and Palestinian sections of the JV

The strategic plan for the JV was developed through an integrated and participatory planning framework (Nikolaidis et al., 2025), specifically designed for the WEFE nexus. The framework, illustrated in Figure 2, is both general and adaptable, enabling methodological customization to suit the unique socio-ecological and political characteristics of a given region. It consists of two main phases:

Phase A: Stakeholder-informed assessment and knowledge co-production

Phase B: Co-design of strategic WEFE solutions for climate change adaptation and mitigation

Strategic Planning Phase A

Phase A laid the foundational basis for the strategic plan. The goal of Phase A was to generate a shared evidence base, elicit local knowledge, and identify priority challenges, capacities, and gaps across the two territories (Jordan and Palestine). The process was highly participatory, involving a series of national and transnational living labs, where stakeholders co-created knowledge and provided direct input into the formulation of strategic directions. The following steps summarize the specific process used in Phase A to develop the strategic plan.

Step 1: Mapping the WEFE Nexus Baseline

A comprehensive mapping of the WEFE nexus was the first step, aiming to document the current state of water, energy, food, and ecosystem resources, their interdependence, and the governance context. This foundational work supported the strategic planning process by ensuring all participants shared a common understanding of the system baseline.

- Data Collection: Key data sources included national ministries (e.g., Ministries of Water, Energy, and Agriculture), international agencies (e.g., FAO, World Bank), and local NGOs. These datasets provided the factual grounding for stakeholder deliberations and methodological analyses.
- Mathematical Modelling: Three models were used to quantify the status of WEFE systems: the Karst-SWAT for hydrological analysis, the MYWAS for multi-year water allocation and the NREL-SAM for renewable energy assessment. The outputs of these models informed both the diagnostic assessment and the early design of WEFE solution alternatives that developed in Phase B.

Step 2: Participatory Systems Mapping (PSM)

The strategic planning process then moved to stakeholder-engaged systems thinking, using Causal Loop Diagrams (CLDs) to map key feedbacks, trade-offs, and leverage points in the WEFE nexus. CLDs were developed collaboratively during the living labs, with stakeholders from each territory contributing their perceptions of system drivers and bottlenecks. The resulting diagrams served as a shared visual reference, enabling cross-sectoral understanding and surfacing systemic challenges. This method ensured that the emerging strategy would be grounded in both empirical evidence and local systems knowledge, identifying where high-leverage interventions might have the greatest impact.

Step 3: Community Capacity Assessment (CCA)

To guide the feasibility and equity of strategic options, a Community Capacity Assessment was conducted to explore the social and institutional readiness of each region to implement change. This was carried out through a transnational living lab setting, where local actors from Jordan and Palestine identified and discussed existing assets (e.g., knowledge, networks, organizational strength) and capacity needs for WEFE governance and innovation. The CCA informed the strategic plan by identifying capacity gaps in areas such as technical training, institutional coordination, youth engagement, and adaptive governance. This ensured that strategy development was not only about designing technical solutions but also about investing in the enabling conditions for sustainable implementation.

Step 4: Gap Analysis Using Key Performance Indicators (KPIs)

The final step in Phase A involved a structured gap analysis, using expert-defined KPIs to compare current WEFE system performance with desired future outcomes. For each challenge defined in the previous steps, a set of KPIs were used. For each KPI, the gap between baseline conditions and strategic targets was quantified.

Strategic Planning Outcomes of Phase A

The implementation of Phase A enabled the co-production of the strategic planning framework and directly informed the structure of the strategic plan for the JV. Specifically, it:

- Established a shared baseline of system understanding across diverse stakeholders
- Identified cross-border synergies and tensions within the WEFE nexus
- Prioritized strategic challenges and development goals through participatory methods
- Revealed local capacities and institutional gaps that the strategy must address
- Framed key indicators and targets to measure progress and impact in Phase B.

Together, the three core methods, Participatory Systems Mapping, Community Capacity Assessment, and Gap Analysis, provided an evidence-based, stakeholder-validated foundation for the co-design of strategic WEFE solutions that was carried in Phase B.

Strategic Planning Phase B

As part of the strategic planning process of Phase B for Jordan and Palestine, a structured methodology was followed to identify and assess effective measures within the WEFE nexus to combat desertification in the JV.

Step 5. Setting up program of measures

The first step involved linking WEFE-related challenges with their underlying drivers, an essential process for uncovering viable solutions and evaluating their potential impact (Pellegrini et al., 2023). These identified challenges and drivers were then mapped to NBS, other hybrid solutions and targeted strategies relevant to the JV context (Nikolaidis et al., 2025). This mapping was informed by methodologies developed by the PRIMA project 'LENSES' and the Horizon 2020 project 'ThinkNature,' both of which provide robust frameworks for designing context-specific NBS. In particular, the NBS tool developed by Vanino et al. (2024) offered a comprehensive catalogue of solutions, including detailed information on NBS typologies, associated ecosystem services, addressed challenges, and alignment with the Sustainable Development Goals (SDGs). The selection of the NBS and hybrid solutions was reinforced by the EcoFuture pilot demonstration conducted in the two territories of the JV which demonstrated the efficacy and effectiveness of key solutions that address WEFE specific challenges to each territory. Additionally, a set of horizontal measures that deal with training, capacity building, education and further research and development were integrated in the program of Measures to ensure coherence with broader regional and international environmental strategies. These horizontal measures were derived from the National and Transnational living lab meeting with the stakeholders and identify a key need. Tables 5-7 and Appendix A present the final list of proposed measures and their descriptions.

Step 6. Technoeconomic evaluation of measures

The hydrologic model Karst-SWAT is a watershed-based model that accounts for the spatial variability of the watershed by subdividing it into sub-catchments. The model is calibrated Hydrologic Response Units (HRUs)., the available water in every sub-basin can be estimated as well as future scenarios of climate change can be simulated to assess the impact of climate change on water availability. Integrated Critical Zone (ICZ) Model coupled with the hydrologic model Karst-SWAT simulates the ecosystem services provided by the JV. The MYWAS-VALUE model to simulate various scenarios and assess their implications on the water and agricultural economies can be also used to evaluate the performance of certain measures.

Step 7. Multicriteria Decision Analysis

As part of Phase B, a Multi-Criteria Decision Analysis (MCDA) was selected as the most appropriate methodology to support participatory and evidence-based decision-making.

Strategic Planning Outcomes of Phase B

This approach comprising steps 5-7 enabled the systematic evaluation and prioritization of the identified measures, taking into account diverse stakeholder perspectives and multiple criteria. Different MCDA algorithms have been applied corresponding to utilitarian and egalitarian rationales so that to implement alternative prioritization then compare different rankings that enables comprehensive analysis and critical discussion of the outcome among policy makers.

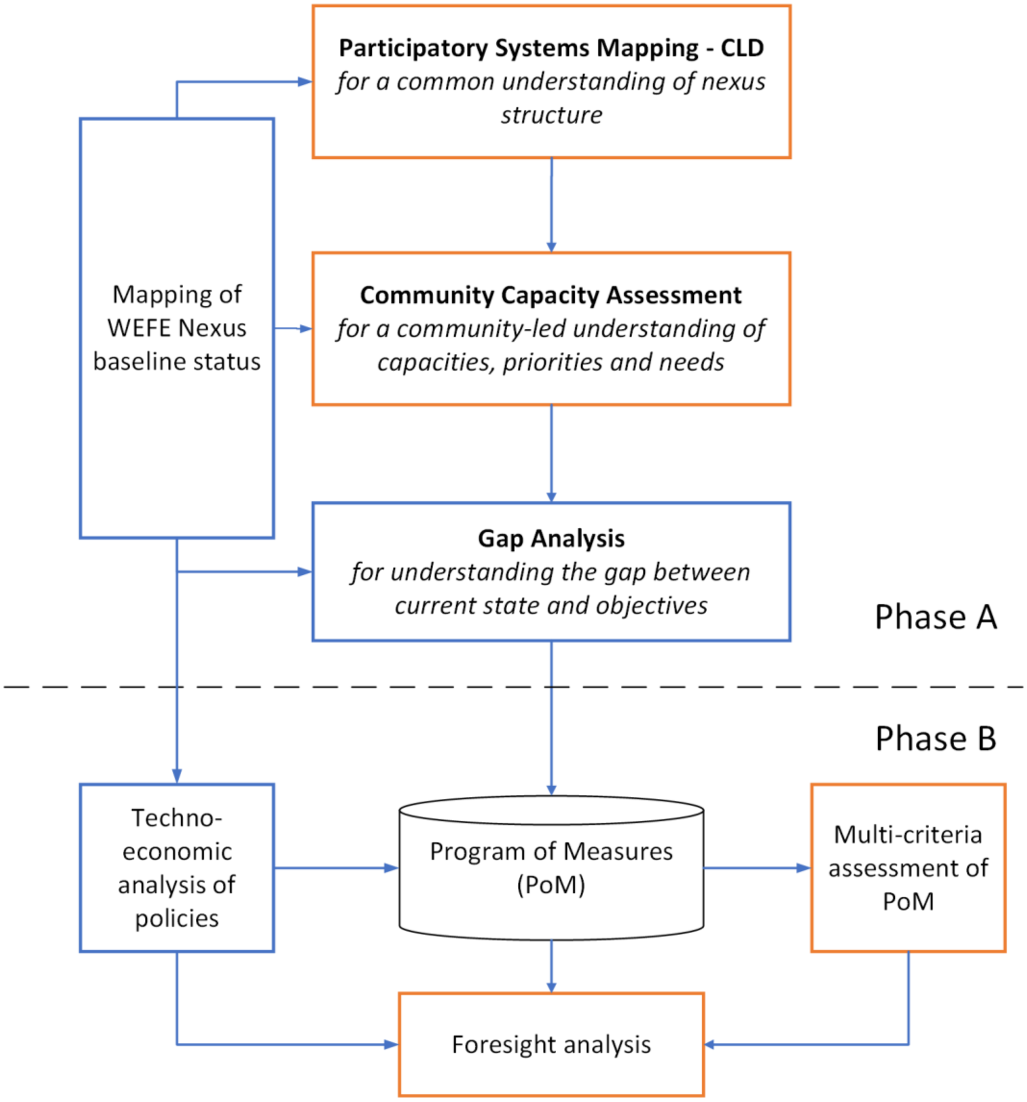


Figure 2. An integrated framework for participatory strategic planning in the WEFE nexus. The methodologies that were conducted with stakeholder participation in living labs are signified with an orange borderline. CLD: Causal Loop Diagrams. (Nikolaidis et al., 2025)

Table 5. List of water security and energy security measures and actions to address desertification in the Jordanian and Palestinian sections of the JV

Water security measures (W)

CATEGORY W1. WATER LOSS REDUCTION

- Measure W1.1 Technology-Driven Water Loss Detection & Infrastructure Repair
- Measure W1.2 Reducing Water Losses in Agricultural Ponds

CATEGORY W2. EFFICIENT IRRIGATION PRACTICES. ADVANCING WATER-SAVING IRRIGATION PRACTICES

- Measure W2.1 Installation of Soil Moisture Meters and Data Transmitters
- Measure W2.2 Development of a Mobile Application for Smart Irrigation Management
- Measure W2.3 Enhancing Soil Coverage to Conserve Moisture
- Measure W2.4 Improving Pressure Uniformity in Irrigation Systems

CATEGORY W3: RAINWATER HARVESTING FOR SUSTAINABLE IRRIGATION

- Measure W3.1 Implementation of Rainwater Collection Systems

CATEGORY W4: DESALINATION OF BRACKISH GROUNDWATER FOR FRESHWATER PRODUCTION

- Measure W4.1 Desalination of Brackish Groundwater

CATEGORY W5: ADVANCED WASTEWATER TREATMENT AND REUSE

- Measure W5.1 Implement secondary wastewater treatment to remove organic matter & tertiary treatment to further improve water quality (through filtration, disinfection, and nutrient removal), to ensure safe reuse in irrigation.

Energy security measures (E)

CATEGORY E.1: ADVANCING SOLAR ENERGY TECHNOLOGIES FOR SUSTAINABLE WATER AND ENERGY MANAGEMENT

- Measure E 1.1 Integrated Systems for Water and Energy Management
- Measure E 1.2 Adoption of Agrivoltaics for Sustainable Agriculture

CATEGORY E.2: IMPLEMENTING EFFICIENT ENERGY PRACTICES FOR SUSTAINABILITY

- Measure E 2.1 Sustainable Energy Practices in Agriculture

CATEGORY E.3: BIOMASS UTILIZATION FOR RENEWABLE ENERGY AND ORGANIC FERTILIZER PRODUCTION

- Measure E 3.1 Biomass and Organic Waste Collection
- Measure E 3.2 Organic Fertilizer Production from Biomass Residues
- Measure E 3.3 Biogas Production

Table 6. List of food security and ecosystem sustainability measures and actions to address desertification in the Jordanian and Palestinian sections of the JV

Food security measures (F)

CATEGORY F.1: AGROECOLOGICAL PRACTICES

- Measure F 1.1 Carbon Addition for Soil Health and Climate Resilience
- Measure F 1.2 Permaculture and Agroforestry for Sustainable Land Use

Ecosystem sustainability measures (Ec)

CATEGORY EC.1: ENHANCING FARMLAND SUSTAINABILITY THROUGH NON-PRODUCTIVE LANDSCAPE ELEMENTS

- Measure Ec 1.1 Nature-Inclusive Agriculture (NIA) for Biodiversity and Ecosystem Services
- Measure Ec 1.2 Integrating Hedgerows and Flower Strips for Biodiversity and Habitat Creation

CATEGORY EC.2: PHYTOREMEDIATION FOR WATER AND SOIL RESTORATION

- Measure Ec 2.1 Implement phytoremediation in contaminated sites.

CATEGORY EC.3: ESTABLISHMENT OF BIOMASS BUFFER STRIPS FOR WATER AND SOIL CONSERVATION

- Measure Ec 3.1 Plant riparian Buffer Strips

CATEGORY EC.4: FENCING FOR BIODIVERSITY CONSERVATION AND LANDSCAPE CONNECTIVITY

- Measure Ec 4.1 Install and Maintain Conservation Fencing

CATEGORY EC.5: TERRACING FOR EROSION CONTROL AND WATER QUALITY PROTECTION

- Measure Ec 5.1 Construct and Maintain Terraces

CATEGORY EC.6: IN-STREAM SMALL DAMS FOR SEDIMENT CONTROL IN WADIES

- Measure Ec 6.1 Design and Construct Small Dams

CATEGORY EC.7: ESTABLISHMENT OF CONSTRUCTED WETLANDS FOR WASTEWATER TREATMENT AND POLLUTANT REMOVAL

- Measure Ec 7.1 Design and Construction of Constructed Wetlands - Site Identification and Planning

CATEGORY EC.8: WETLAND RESTORATION FOR ECOSYSTEM HEALTH AND WATER QUALITY IMPROVEMENT

- Measure Ec 8.1 Wetland restoration

CATEGORY EC.9: ESTABLISHMENT OF ECOLOGICAL CORRIDORS FOR ENHANCING CONNECTIVITY IN TERRESTRIAL ECOSYSTEMS

- Measure Ec 9.1 Design and Plan Ecological Corridors

CATEGORY EC.10: PLAN AND ESTABLISH NEW PROTECTED AREAS OR ENHANCE MANAGEMENT OF EXISTING PROTECTED AREAS FOR BIODIVERSITY CONSERVATION

- Measure Ec 10.1 Design and Establish New Protected Areas
- Measure Ec 10.2 Enhance the Management of Existing Protected Areas

Table 7. List of horizontal measures and actions to address desertification in the Jordanian and Palestinian sections of the JV

Horizontal measures (H)

CATEGORY H.1: EDUCATIONAL MEASURES

- Measure H1.1 Professional Training of Farmers and Livestock Breeders
- Measure H1.2 Public Awareness and Sensitization on Water Issues
- Measure H1.3 Enhancing Environmental Programs in Primary & Secondary & Higher Education

CATEGORY H.2: RESEARCH, DEVELOPMENT AND DEMONSTRATION PROJECTS

- Measure H2.1 Pilot Measures for the Implementation of Precision Agriculture.
- Measure H2.2 Installation of Monitoring Stations for different purposes.

Prioritization of Measures

5. Prioritization of measures with Multi-Criteria Decision Analysis (MCDA)

Problems that arise across the WEFE nexus, as well as their solutions, essentially span different sectors, affect diverse social groups, and touch on many dimensions of sustainability. In the JV, this complexity is further intensified by the region's transboundary character, long-standing conflicts among the three riparian countries, and ongoing war conditions. As such, the prioritization of alternative WEFE measures for the JV presents a highly complex, multidimensional decision-making challenge.

MCDA was selected as the most appropriate method to support decision-making in this context. MCDA is a family of appraisal techniques that enable the structured comparison of alternatives across multiple, often conflicting, criteria, while explicitly incorporating the preferences of different stakeholders. It is widely used for strategic planning and sustainability assessment processes and increasingly applied in WEFE nexus studies. It is especially suitable for participatory processes, as it allows transparency, stakeholder interaction, and can be adapted to diverse data types and decision contexts.

5.1 MCDA methodology

Goal and scope

The aim of the MCDA process is to assess and rank alternative measures that can optimize the WEFE nexus and enhance well-being in the Palestinian and Jordanian parts of the JV. The final objective is to identify the top-ranked measures to be included in each country's national strategic plan.

Definition of alternatives

Drawing on the outputs of Phase A of the EcoFuture strategic planning framework, an initial list of WEFE measures was compiled to address critical challenges related to the security of water, energy, food, and ecosystems. This list was refined through consultation with Jordanian and Palestinian project partners to ensure contextual relevance, practical feasibility, and alignment with national priorities. The final list represents a jointly agreed-upon set of measures to be assessed.

Definition of criteria and indicators

A multi-criteria framework was developed to assess the alternative measures across several key dimensions of sustainable development and WEFE nexus management in the JV. The definition of criteria was informed by:

- A review of the scientific literature in the intersection of MCDA and WEFE nexus or Nature-Based Solutions (NBS),
- Relevant institutional frameworks, including the UN Sustainable Development Goals (SDGs) and the IUCN Global Standard for NBS,
- Insights generated during Phase A of EcoFuture's strategic planning process, especially those related to the region's key challenges.

The final criteria are organized into four main categories:

1. **Key challenges & environmental sustainability**: Assesses how each measure contributes to addressing the region's most pressing WEFE challenges, while maintaining or enhancing ecosystem health, biodiversity, and resource sustainability.
2. **Social equity, community empowerment, and well-being**: Captures the inclusiveness and fairness of resource management, with emphasis on benefit distribution, community engagement, and improvements to public health and local capacities.

3. **Economic benefits and affordability**: Evaluates whether the measures generate economic opportunities, such as income and job creation, and whether they are financially accessible to affected stakeholders and communities.
4. **Implementation feasibility and operational sustainability**: Assesses whether each measure is practical, technically mature, culturally and institutionally compatible, and manageable within the socio-economic conditions of the region.

Subsequently, criteria were specified for each category, and the framework was validated by the project partners. The full criteria hierarchy is visualized in a three-level decision tree (Figure 3).

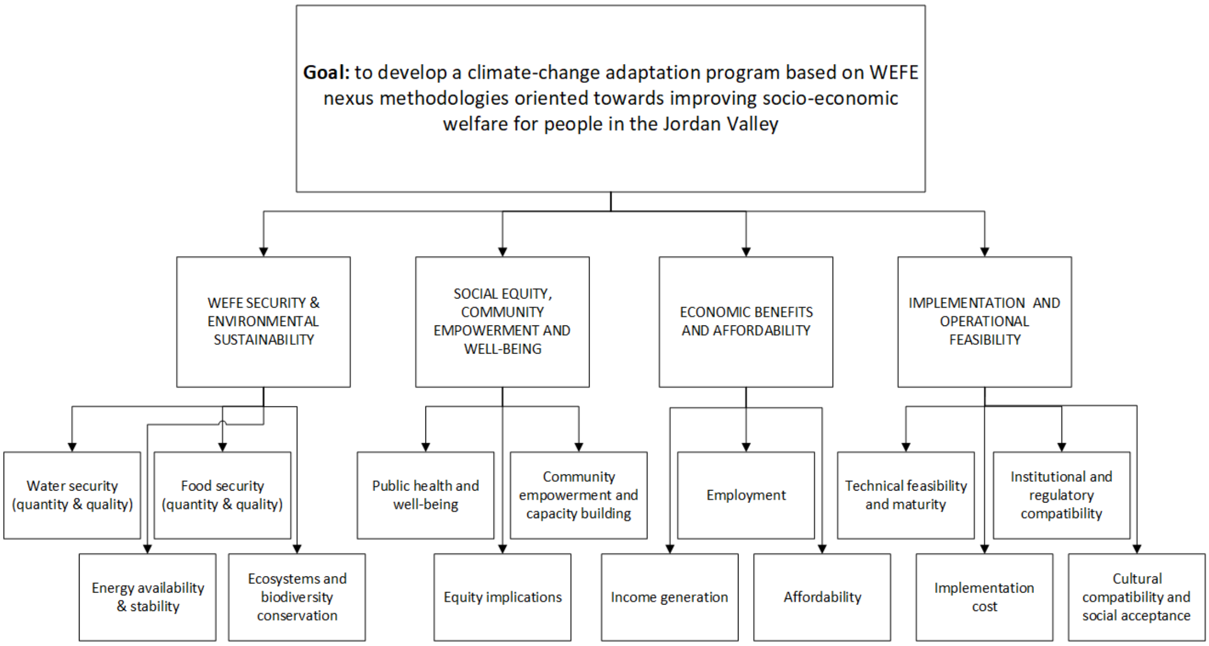


Figure 3. Hierarchical decision tree. Level 1: Goal of the assessment; Level 2: Criteria categories; Level 3: Criteria. A detailed description of all criteria is provided in Appendix B.

Definition of alternatives' performance

Each alternative measure was evaluated across all criteria using a qualitative scale from -3 to +3, where:

- **-3** indicates highly negative performance,
- **0** represents neutral or no significant impact, and
- **+3** indicates highly positive performance.

The scoring scale for each criterion is described in detail in Appendix C. Initial scores were assigned by the expert team at the Technical University of Crete (TUC), drawing on expertise in environmental management, environmental economics, and sustainability science. These scores were subsequently reviewed and validated by the project partners in Jordan and Palestine to reflect their expertise and contextual knowledge and ensure local relevance. The final performance matrix is included in Appendix D.

Elicitation of weights

A two-step process was used to determine the relative importance (weights) of the criteria. Initially, a pilot assessment was performed internally by the consortium, using equal weights for criteria categories and scenario-based variations (emphasizing one criterion category at a time). This served as a sensitivity test to observe how rankings shift under different weighting assumptions. It also shared with workshop participants in the TLL to illustrate to them the importance of weight elicitation process.

During the transnational Living Lab held in Jordan, stakeholders from both Jordan and Palestine were invited to express their preferences regarding criteria importance. The Simos method (Figueira and Roy, 2002) was used to facilitate this process. This method is particularly used to weight the criteria and is developed based on card games. According to the literature, it is preferred for its simplicity and practicality in the eyes of the decision makers (DMs).

Initially, the DM uses a set of cards. On each card, the name of one criterion is written. The DM also has a set of white cards. First, as shown in the picture below, the DM ranks the criteria cards from the least to the most important. If some criteria are considered by the DM to have the same importance (ex aequo criteria), they are situated into the same rank (Figure 4). Afterward, the DM defines the distance of weights between two successive ranks by inserting (or not inserting) white cards between them. No white card means that the criteria of 2 successive ranks do not have the same weight and that the difference between their weights can be taken as the smallest acceptable interval (the unit for measuring the intervals between weights), let's call it "u". For each white card inserted, one more u is added between two successive ranks. Afterward, the non-normalized and normalized criteria weights through the Simos method algorithm can be calculated.

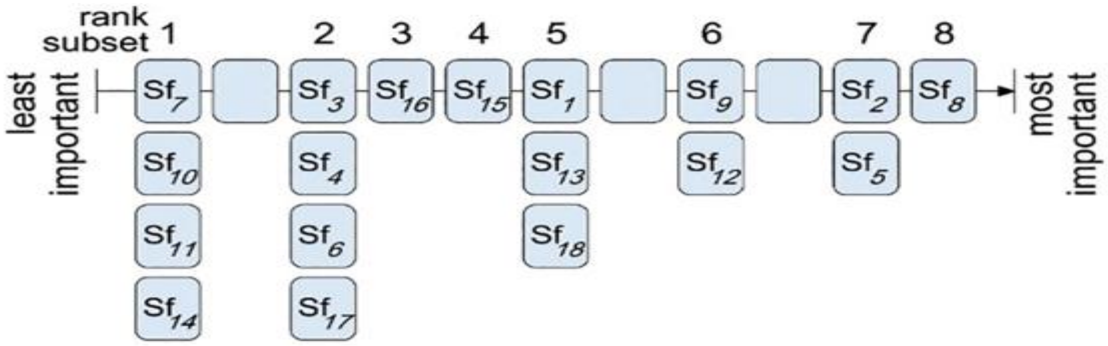


Figure 4. Illustration of weighting criteria with the Simos method

Implementation of the decision algorithm and ranking of alternatives

Subsequently, the alternatives were assessed and ranked using the weighted sum method (WSM), a simple and widely used technique that aggregates weighted performance scores across all criteria for each alternative.

$$Score_i = \sum_{j=1}^{n} w_j s_{ij}$$

where:

- $Score_i$ is the overall score of alternative i,
- w_j is the weight of criterion j,
- s_{ij} is the performance score of alternative i on criterion j.

Although the weighted sum is a fully compensatory method (i.e., a poor score in one criterion can be offset by a high score in another) it was selected for its simplicity, transparency, and suitability for large sets of alternatives and participatory settings. These features made it particularly practical to use during the transnational living lab, where decision transparency and interpretability were critical.

However, to overcome the compensatory nature of WSM, the Minimax algorithm was also applied. The Minimax algorithm translates into simple algorithmic terms the egalitarian principle, often used in environmental management, paticularly in the presence of different categories of criteria. The max-min rule or Rawlsian rule implies that, among all possible alternatives, society should pick the alternative which maximizes the *minimum utility* of all individuals in society or minimizing the maximum damage in terms of environmental objectives. It is a formal mathematical representation of the egalitarian philosophy contrasting the utilitarian approach of the weighted sum. It translates in operational terms the Difference Principle, which says that inequalities of resources should be to the benefit of the less fortunate, or more specifically, that allocations of resources should be ranked by the maximin criterion.

The algorithm is specified in the following steps:

1. One calculates the distance from a reference point (target) for all criteria, as follows:

$$\text{distance (X) for criterion } \psi = [\text{target} - \text{performance (X)}] / (\text{max} - \text{min})$$

2. The maximum distance of each alternative on all criteria (last column) is calculated
3. Finally, one determines the least distance and the alternative containing the least distance is chosen

In our implementation, the Minimax method incorporated the stakeholder-derived weights to reflect the relative importance of each criterion. The weighted distance was calculated as follows:

$$\text{weighted distance (X) for criterion } \psi = \text{weight}_{\psi} * [\text{target} - \text{performance (X)}] / (\text{max} - \text{min})$$

5.2 Stakeholder Engagement – Transnational Living Lab

Objectives of the Jordanian-Palestinian Transnational Living Lab

The Jordanian-Palestinian TLL workshop was conducted on 28-30th April 2025 at the Dead Sea, in Jordan. It brought together a diverse group of over 40 stakeholders from Jordan and Palestine, including policymakers, farmers, researchers, technical experts and civil society representatives, to collaboratively assess and prioritize WEFE nexus strategies aimed at reducing vulnerability to desertification and climate change in the JV. The primary objectives of the workshop were to:

- Discuss and identify effective WEFE-aligned alternatives and strategies at the catchment level (program of measures) that can be tailored to the specific contexts of Jordan and Palestine;
- Prioritize these alternative solutions using a MCDA, allowing for the systematic evaluation of options based on multiple, stakeholder-defined criteria;
- Identify key barriers to implementation, distinguishing between internal (e.g., governance, institutional capacity) and external (e.g., climatic, economic) driving and constraining factors;
- Shortlist high-impact solutions and strategies with strong potential for implementation and scalability;
- Synthesize selected actions into coherent national strategies that maximize the impact of the overall transboundary strategic plan.

As part of the participatory MCDA process, stakeholders were actively engaged in the following activities:

- Reviewing the proposed alternatives and the evaluation criteria;

- Assigning relative importance (weights) to each criterion based on their preferences and expertise;
- Providing or validating the performance assessments of each alternative with respect to the selected criteria.

This participatory framework allowed stakeholders to:

- Visualize the implications of their preferences on the prioritization results;
- Engage in dialogue to reflect on the robustness and fairness of the assessment;
- Suggest and, if necessary, modify parameters such as alternatives, criteria, weights, or performance scores to improve the quality and relevance of the analysis.

Key Achievements

- Established a shared understanding of key regional challenges linked to desertification and WEFE interdependencies;
- Co-developed integrated, context-specific solutions that bridge the WEFE nexus and national priorities;
- Formulated actionable implementation frameworks, informed by local knowledge and cross-sectoral input;
- Strengthened transboundary collaboration and trust, fostering a foundation for sustained joint planning and coordinated action.

5.3 Priorities - MCDA Results

Criteria weights

The calculated weights assigned to the criteria by different stakeholder groups are presented in Table 8. While slight variations can be observed among groups (e.g., between Jordanian and Palestinian participants or between policymakers and farmers), overall the weights were found to be sufficiently convergent to justify the use of an average weight set for the multi-criteria analysis.

Table 8. The relative importance assigned to the criteria by different stakeholder groups derived with the Simos method.

	1.1 Water security (quantity & quality)	1.2 Energy availability & stability	1.3 Food security (quantity & quality)	1.4 Ecosystems and biodiversity conservation	2.1 Public health and well-being	2.2 Equity implications	2.3 Community empowerment and capacity building	3.1 Income generation	3.2 Employment	3.3 Affordability	4.1 Technical feasibility and maturity	4.2 Implementation cost	4.3 Institutional and regulatory compatibility	4.4 Cultural compatibility and social acceptance
Jordan	10.96%	8.97%	8.86%	6.40%	7.53%	5.78%	7.01%	7.03%	6.75%	6.40%	5.37%	7.23%	5.18%	6.53%
Palestine	11.09%	10.07%	10.60%	8.17%	6.74%	5.37%	4.93%	8.29%	6.73%	6.57%	6.49%	4.92%	4.77%	5.27%
Farmers	11.30%	9.97%	8.06%	5.87%	6.31%	6.72%	7.43%	7.33%	6.24%	5.90%	5.35%	6.95%	5.26%	7.33%
Scientists - Policymakers	10.78%	8.16%	9.91%	7.15%	8.19%	5.45%	6.58%	6.23%	7.01%	6.27%	5.25%	7.22%	5.57%	6.23%
Policymakers	10.98%	9.82%	9.89%	7.51%	7.16%	5.14%	5.49%	8.44%	6.85%	6.94%	6.34%	5.64%	4.50%	5.30%
Average weights	**11.00%**	**9.32%**	**9.42%**	**6.97%**	**7.27%**	**5.65%**	**6.34%**	**7.44%**	**6.74%**	**6.45%**	**5.73%**	**6.49%**	**5.04%**	**6.12%**

Ranking of alternatives

The ranking of the alternative WEFE measures is presented in Tables 9 and 10, for the weighted sum and the Minimax method respectively. For the purposes of comparison, only "vertical" measures are included in the ranking, while "horizontal" measures (generic support actions such as training and awareness) are excluded, as these are considered beneficial across all scenarios and are intended to be adopted regardless of score. The averaged weights representing the whole group of stakeholders are used for these rankings.

Table 9. Ranking of alternative measures based on the weighted sum method. Horizontal measures are not included in this ranking. Results are calculated using the averaged weights representing the whole group of stakeholders.

MEASURES SORTED BY WSM RESULT	WSM RESULT	RANKING
W3.1 Implementation of Rainwater Collection Systems	2.117	1
Ec1.1 Nature-Inclusive Agriculture (NIA) for Biodiversity and Ecosystem Services	1.703	2
W1.1 Technology-Driven Water Loss Detection & Infrastructure Repair	1.593	3
W2.2 Development of a Mobile Application for Smart Irrigation Management	1.417	4
Ec5.1 Construct and Maintain Terraces	1.407	5
W2.4 Improving Pressure Uniformity in Irrigation Systems	1.370	6
E3.2 Organic Fertilizer Production from Biomass Residues	1.363	7
F1.1 Carbon Addition for Soil Health and Climate Resilience	1.343	8
F1.2 Permaculture and Agroforestry for Sustainable Land Use	1.321	9
Ec10.2 Enhance the Management of Existing Protected Areas	1.293	10
Ec1.2. Integrating Hedgerows and Flower Strips for Biodiversity and Habitat Creation	1.239	11
E3.1 Biomass and Organic Waste Collection	1.234	12
W5.1 Implement secondary wastewater treatment to remove organic matter & tertiary treatment to further improve water quality, to ensure safe reuse in irrigation	1.226	13
W2.3 Enhancing Soil Coverage to Conserve Moisture	1.218	14
Ec3.1 Plant riparian Buffer Strips	1.191	15
Ec10.1 Design and Establish New Protected Areas	1.191	16
E1.1 Integrated Systems for Water and Energy Management	1.179	17
W2.1 Installation of Soil Moisture Meters and Data Transmitters	1.168	18
Ec2.1 Implement phytoremediation in contaminated sites	1.112	19
Ec8.1 Wetland restoration	1.071	20
Ec4.1 Install and Maintain Conservation Fencing	1.068	21
W1.2 Reducing Water Losses in Agricultural Ponds	1.020	22
Ec9.1 Design and Plan Ecological Corridors	0.814	23
E1.2 Adoption of Agrivoltaics for Sustainable Agriculture	0.757	24
E2.1 Sustainable Energy Practices in Agriculture	0.738	25
Ec6.1 Design and Construct Small Dams	0.730	26
W4.1 Desalination of Brackish Groundwater	0.573	27
E3.3 Biogas Production	0.521	28
Ec7.1 Design and Construction of Constructed Wetlands – Site Identification and Planning	0.520	29

Table 10. Ranking of alternative measures based on the minimax method. Horizontal measures are not included in this ranking. Results are calculated using the averaged weights representing the whole group of stakeholders

MEASURES SORTED BY MINMAX RESULT	RANKING	
W3.1 Implementation of Rainwater Collection Systems	1	1
E1.2 Adoption of Agrivoltaics for Sustainable Agriculture	2	2
E3.2 Organic Fertilizer Production from Biomass Residues	2	3
Ec10.1 Design and Establish New Protected Areas	2	4
W1.1 Technology-Driven Water Loss Detection & Infrastructure Repair	5	5
W1.2 Reducing Water Losses in Agricultural Ponds	5	6
W2.1 Installation of Soil Moisture Meters and Data Transmitters	5	7
W2.2 Development of a Mobile Application for Smart Irrigation Management	5	8
W2.4 Improving Pressure Uniformity in Irrigation Systems	5	9
E1.1 Integrated Systems for Water and Energy Management	5	10
F1.1 Carbon Addition for Soil Health and Climate Resilience	5	11
F1.2 Permaculture and Agroforestry for Sustainable Land Use	5	12
Ec1.1 Nature-Inclusive Agriculture (NIA) for Biodiversity and Ecosystem Services	5	13
Ec5.1 Construct and Maintain Terraces	5	14
Ec10.2 Enhance the Management of Existing Protected Areas	5	15
Ec6.1 Design and Construct Small Dams	16	16
E2.1 Sustainable Energy Practices in Agriculture	17	17
E3.1 Biomass and Organic Waste Collection	17	18
E3.3 Biogas Production	17	19
W2.3 Enhancing Soil Coverage to Conserve Moisture	20	20
Ec1.2. Integrating Hedgerows and Flower Strips for Biodiversity and Habitat Creation	20	21
Ec2.1 Implement phytoremediation in contaminated sites	20	22
Ec3.1 Plant riparian Buffer Strips	20	23
Ec4.1 Install and Maintain Conservation Fencing	20	24
Ec7.1 Design and Construction of Constructed Wetlands - Site Identification and Planning	20	25
Ec8.1 Wetland restoration	20	26
Ec9.1 Design and Plan Ecological Corridors	20	27
W4.1 Desalination of Brackish Groundwater	28	28
W5.1 Implement secondary wastewater treatment to remove organic matter & tertiary treatment to further improve water quality to ensure safe reuse in irrigation	28	29

Analysis of results

By comparing the results from the two methods, several insights emerge. First, WSM provides a complete ranking, while Minimax yields clusters of equally ranked alternatives, reflecting its egalitarian logic that prioritizes minimizing the worst shortfall across all criteria.

A comparison of the top 15 measures under each method is presented in Table 11. The table reveals a substantial degree of convergence between the two methods. All of the ten highest-ranked WSM measures appear within the top 15 of the Minimax results. This indicates a shared core of prioritized measures, regardless of the decision logic applied. Among these, "W3.1: Implementation of Rainwater Collection Systems" ranks first in both methods, confirming its high performance across WEFE and sustainability dimensions and its strong contextual fit for the JV.

Table 11. Comparative view of rankings with the two methods (first fifteen measures). Common measures in both Top 15 lists are presented with bold.

WSM ranking		Minimax ranking	
W3.1 Implementation of Rainwater Collection Systems	1	**W3.1 Implementation of Rainwater Collection Systems**	1
Ec1.1 Nature-Inclusive Agriculture (NIA) for Biodiversity and Ecosystem Services	2	E1.2 Adoption of Agrivoltaics for Sustainable Agriculture	2
W1.1 Technology-Driven Water Loss Detection & Infrastructure Repair	3	**E3.2 Organic Fertilizer Production from Biomass Residues**	2
W2.2 Development of a Mobile Application for Smart Irrigation Management	4	Ec10.1 Design and Establish New Protected Areas	2
Ec5.1 Construct and Maintain Terraces	5	**W1.1 Technology-Driven Water Loss Detection & Infrastructure Repair**	5
W2.4 Improving Pressure Uniformity in Irrigation Systems	6	W1.2 Reducing Water Losses in Agricultural Ponds	5
E3.2 Organic Fertilizer Production from Biomass Residues	7	W2.1 Installation of Soil Moisture Meters and Data Transmitters	5
F1.1 Carbon Addition for Soil Health and Climate Resilience	8	**W2.2 Development of a Mobile Application for Smart Irrigation Management**	5
F1.2 Permaculture and Agroforestry for Sustainable Land Use	9	**W2.4 Improving Pressure Uniformity in Irrigation Systems**	5
Ec10.2 Enhance the Management of Existing Protected Areas	10	E1.1 Integrated Systems for Water and Energy Management	5
Ec1.2. Integrating Hedgerows and Flower Strips for Biodiversity and Habitat Creation	11	**F1.1 Carbon Addition for Soil Health and Climate Resilience**	5
E3.1 Biomass and Organic Waste Collection	12	**F1.2 Permaculture and Agroforestry for Sustainable Land Use**	5
W5.1 Implement secondary wastewater treatment to remove organic matter & tertiary treatment to further improve water quality to ensure safe reuse in irrigation	13	**Ec1.1 Nature-Inclusive Agriculture (NIA) for Biodiversity and Ecosystem Services**	5
W2.3 Enhancing Soil Coverage to Conserve Moisture	14	**Ec5.1 Construct and Maintain Terraces**	5
Ec3.1 Plant riparian Buffer Strips	15	**Ec10.2 Enhance the Management of Existing Protected Areas**	5

These ten top-ranked interventions emphasize the urgent need for sustainable water management, such as the implementation of rainwater collection systems (W3.1), which can significantly enhance water availability, particularly in drought-prone areas. Complementary strategies, including technology-driven water loss detection (W1.1) and smart irrigation applications (W2.2), bring innovation into resource management, increasing efficiency and reducing waste.

Equally critical is the transition toward nature-inclusive agricultural practices (Ec1.1) and land-use systems that restore and protect biodiversity. Approaches such as terracing (Ec5.1) and permaculture and agroforestry (F1.2) not only sustain yields but also improve habitat quality and soil health. These measures are key to reversing environmental degradation while supporting rural livelihoods.

Soil health is another recurring theme, with interventions like carbon addition (F1.1) directly contributing to long-term land productivity and climate resilience. Furthermore, the integration of organic waste management strategies, such as fertilizer production from biomass residues (E3.2), reflects a shift toward circular and regenerative agricultural systems.

Finally, the inclusion of measures to protect and enhance ecosystems, such as improved management of protected areas (Ec10.2, underscores the interconnectedness of land, water, and biodiversity. These actions are vital for maintaining ecological functions and ensuring sustainable resource availability for future generations. Together, these interventions present a comprehensive framework for transforming environmental stewardship in both rural and peri-urban landscapes. Their successful implementation will require cross-sector collaboration, investment in capacity-building, and adaptive governance to ensure that the benefits are widely shared and sustained over time.

Despite overall convergence, notable variations in ranking remain, due to the different decison logic of the two methods. WSM rewards strong cumulative performance, allowing high scores in some criteria to compensate for weaknesses in others. This benefits ambitious or transformative measures with uneven performance profiles. Minimax, by contrast, penalizes even moderate weaknesses in highly weighted criteria, favoring measures with balanced performance in the most critical areas (e.g., water, food, energy security, and income generation). This divergence offers important strategic insights.

For example, "Ec1.1: Nature-Inclusive Agriculture (NIA) for Biodiversity and Ecosystem Services" ranks 2nd under WSM but 5th (tie with other ten measures) under minmax. Its high WSM score is driven by strong positive impacts in biodiversity, well-being, community empowerment and affordability, which compensate for a lower score in technical maturity and moderate score in Water and Food security. In contrast, Minimax penalizes heavily its moderate score on Water security, which is a highly weighted criterion, lowering its overall ranking.

Conversely, "E1.2: Adoption of Agrivoltaics for Sustainable Agriculture", is ranked 2nd with the Minmax but 24th with the WSM. While Ec1.1 scores higher overall, it scores moderately on Income generation, which is a highly weighted criterion, and this cannot be overlooked by the minmax algorithm. On the contrary, E1.2 performs more reliably across highly weighted criteria; hence, its higher rank under Minmax; even if it doesn't achieve excellent scores for any criterion.

Other measures that exhibit this divergence include "W5.1 Implement secondary & tertiary wastewater treatment", "E3.1 Biomass and Organic Waste Collection" and "Ec3.1 Plant riparian Buffer Strips", all of which perform well in several categories but are penalized by minmax for their moderate impact on either water, energy or food security, which are all highly weighted criteria. Conversely, some measures are elevated in the Minmax ranking due to their balanced performance across criteria, particularly the highly weighted ones, even if they do not achieve outstanding scores in any single criterion. These include "Ec10.1 Design and Establish New Protected Areas", "E1.1: Integrated Systems for Water and Energy Management", "W1.2: Reducing Losses in Agricultural Ponds" and "W2.1: Installation of Soil Moisture Meters and Data Transmitters". These are considered more balanced options, with no major weaknesses, and may be especially suitable for early or risk-averse implementation phases.

Overall, the comparative application of two multi-criteria methods has highlighted the strengths and vulnerabilities of each measure, providing valuable guidance for implementation decisions.

5.4. Sensitivity analysis of the weights

To further test the robustness of the ranking, a sensitivity analysis was performed by systematically varying criteria weights around the stakeholder-defined baseline. For each weight scenario, the WSM algorithm was repeated, yielding 50 independent rankings of the 29 alternatives. The agreement among the 50 rankings is extremely high, as quantified by Kendall's W = 0.97, indicating very strong robustness of the ranking to weight perturbations.

Figure 5 shows the distribution of ranks under the 50 weight sets. Some alternatives remain perfectly stable (e.g. W3.1 is consistently ranked first), while others exhibit sensitivity. The most sensitive alternative is W5.1, which ranges between the 7th and 19th positions depending on the weight scenario.

Based on our objective to identify a robust top-performing group for further consideration, we treat the SA results conservatively. Instead of selecting only the top 15 alternatives from the baseline ranking, we retain the top 18 alternatives (up to W2.1), which remain consistently high-performing across virtually all weight sets.

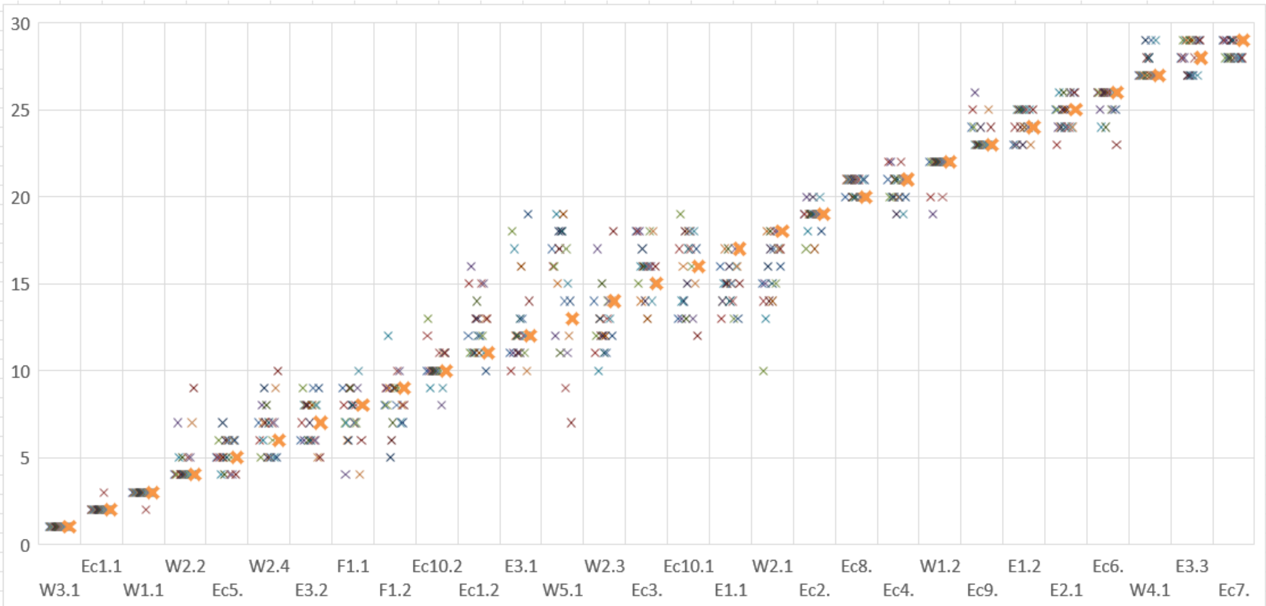


Figure 5. Distribution of the WSM ranks of the 29 alternatives across 50 perturbed weight scenarios (±25% variation around baseline weights), together with the baseline ranking shown as a bold orange series. Stable alternatives show narrow rank ranges (e.g. W3.1), whereas others exhibit moderate sensitivity (e.g. W5.1). Overall, rankings remain highly robust (Kendall's W = 0.97).

A sensitivity analysis was also performed for the Minimax method using 50 perturbed weight sets generated within ±25% of the baseline stakeholder-defined weights (with normalization). The resulting rankings display a moderate-to-high level of concordance, with a Kendall's W of 0.79, indicating that the Minimax prioritization is robust but exhibits more sensitivity to weight variations than the WSM, which had a W of 0.97.

The graphical representation of the rank distributions in Figure 6 reveals that the alternatives clearly cluster in two groups: the first 15 alternatives consistently rank within the top 15 positions across all scenarios, whereas the remaining 14 alternatives consistently occupy lower rankings. This indicates a natural robustness threshold between a high-performing and low-performing group.

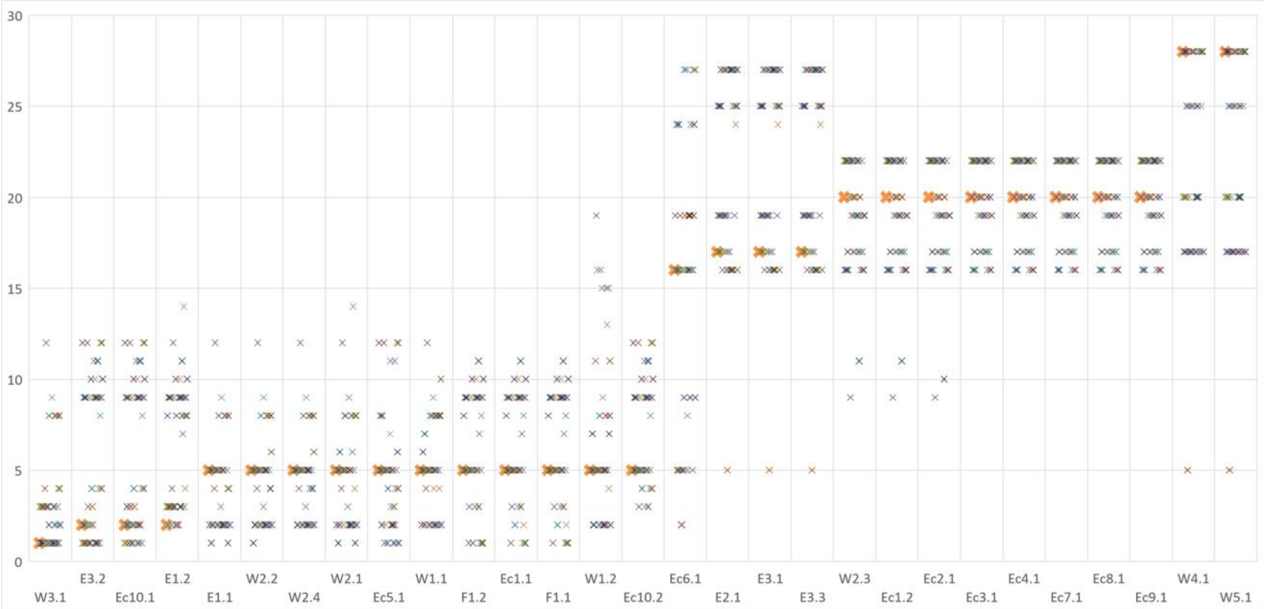


Figure 6. Distribution of the Minimax ranks of the 29 alternatives across 50 perturbed weight sets (±25% variation around baseline weights), together with the baseline ranking shown as a bold orange series. The graph reveals two clusters: the first 15 alternatives consistently rank higher than the remaining 14.

By taking the intersection of the robust groups identified by both methods (WSM and Minimax), we obtain a consistent subset of alternatives that remain in the top-ranked positions across both methods and across all weight perturbations. These 13 alternatives (W3.1, Ec1.1, W1.1, W2.2, Ec5.1, W2.4, E3.2, F1.1, F1.2, Ec10.1, Ec10.2, E1.1, W2.1) can therefore be considered the robust top-performing group, resilient to both preference uncertainty and aggregation-rule uncertainty. This subset represents the most reliable portfolio of measures for further analysis and stakeholder deliberation during the strategic design phase.

5.5 Bundling measures to enhance synergies and feasibility

The set of measures listed in this report are examined not only based on their individual performance across the criteria but also their potential to create synergistic effects across the criteria, if complementarily applied. The following analysis provides opportunities for cross-sectoral bundling, especially for measures that perform well in some areas but are penalized for underperformance in others. Table 12 presents examples of synergistic measure bundles that could enhance implementation feasibility and cross-sectoral benefits. These combinations address underperformance in key criteria and support integrated nexus outcomes.

Each bundle was purposefully constructed to meet a strategic objective while mitigating the weaknesses of its core measure. For example, bundling soil moisture monitoring technologies (W2.1) with rainwater harvesting (W3.1), smart irrigation tools (W2.2), water loss infrastructure repair (W1.1) and improving pressure in irrigation systems (W2.4) improves overall water-use efficiency and technical coherence. Similarly, pairing permaculture practices (F1.2) with agrivoltaics (E1.2) and organic fertilizer production (E3.2) promotes climate smart agriculture while increasing market access and the farmers' income and energy resilience. These thematic bundles also emphasize the role of the horizontal measures proposed such as education, monitoring, and institutional support (e.g., H1.1–H1.5) as catalysts of transformative change.

Table 12. Bundling matrix of WEFE measures

Purpose of bundling	Core measure	Suggested bundled measures
Improve performance in water security and technical feasibility	W2.1 Installation of Soil Moisture Meters and Data Transmitters	W3.1 Implementation of Rainwater Collection Systems
		W1.1 Technology-Driven Water Loss Detection & Infrastructure Repair
		W2.2 Development of a Mobile Application for Smart Irrigation Management
		W2.4 Improving Pressure Uniformity in Irrigation Systems
		H1.4 Pilot Measures for the Implementation of Precision Agriculture
Enhance income generation, energy use, and market access	F1.2 Permaculture and Agroforestry for Sustainable Land Use	E3.2 Organic Fertilizer Production from Biomass Residues
		E1.2 Adoption of Agrivoltaics for Sustainable Agriculture
		H1.1: Professional Training of Farmers and Livestock Breeders
Strengthen environmental safety, nutrient reuse, and governance compliance	W5.1 Implement secondary wastewater treatment to remove organic matter & tertiary treatment to further improve water quality	E3.1 Biomass and Organic Waste Collection
		Ec2.1 Implement phytoremediation in contaminated sites
		H1.5 Installation of Monitoring Stations for different purposes
Maximize co-benefits of water, energy, and food while increasing public understanding and acceptance	F1.1 Carbon Addition for Soil Health and Climate Resilience	W2.1 Installation of Soil Moisture Meters and Data Transmitters
		E1.2 Adoption of Agrivoltaics for Sustainable Agriculture
		H1.2 Public Awareness and Sensitization on Water Issues
Support biodiversity, ecosystem services and cultural transformation through nature-based interventions and educational programs	Ec10.2 Enhance the Management of Existing Protected Areas	Ec1.1: Nature-Inclusive Agriculture
		F1.2 Permaculture and Agroforestry for Sustainable Land Use
		Ec5.1 Construct and Maintain Terraces
		H1.3 Enhancing Environmental Programs in Primary, Secondary & Higher Education

Figure 7 illustrates the performance of each bundle compared to its corresponding core measure, using radar charts that visualize performance across the ten decision criteria. The outer perimeter of the spider graph offers a visual impression of the overall spread and balance of the measures' strengths and weaknesses, highlighting which criteria are strongly supported and where there may be persistent weaknesses. The average line, meanwhile, quantifies the central tendency of the bundle's performance, providing a summary indication of its overall robustness and contribution to nexus goals.

What is particularly striking is how bundling shifts performance profiles from uneven or narrowly focused (as seen in some core measures) to more holistic and synergistic patterns. In the case of bundle 1, while the core intervention (W2.1 Soil moisture meters) shows limitations in dimensions such as equity implications, technical feasibility and maturity and affordability, the addition of well-aligned complementary measures (like rainwater harvesting and infrastructure repair) enhances performance across these criteria. As illustrated in the spider graph, the first bundle overall achieves a more balanced and robust profile compared to the initial core measure.

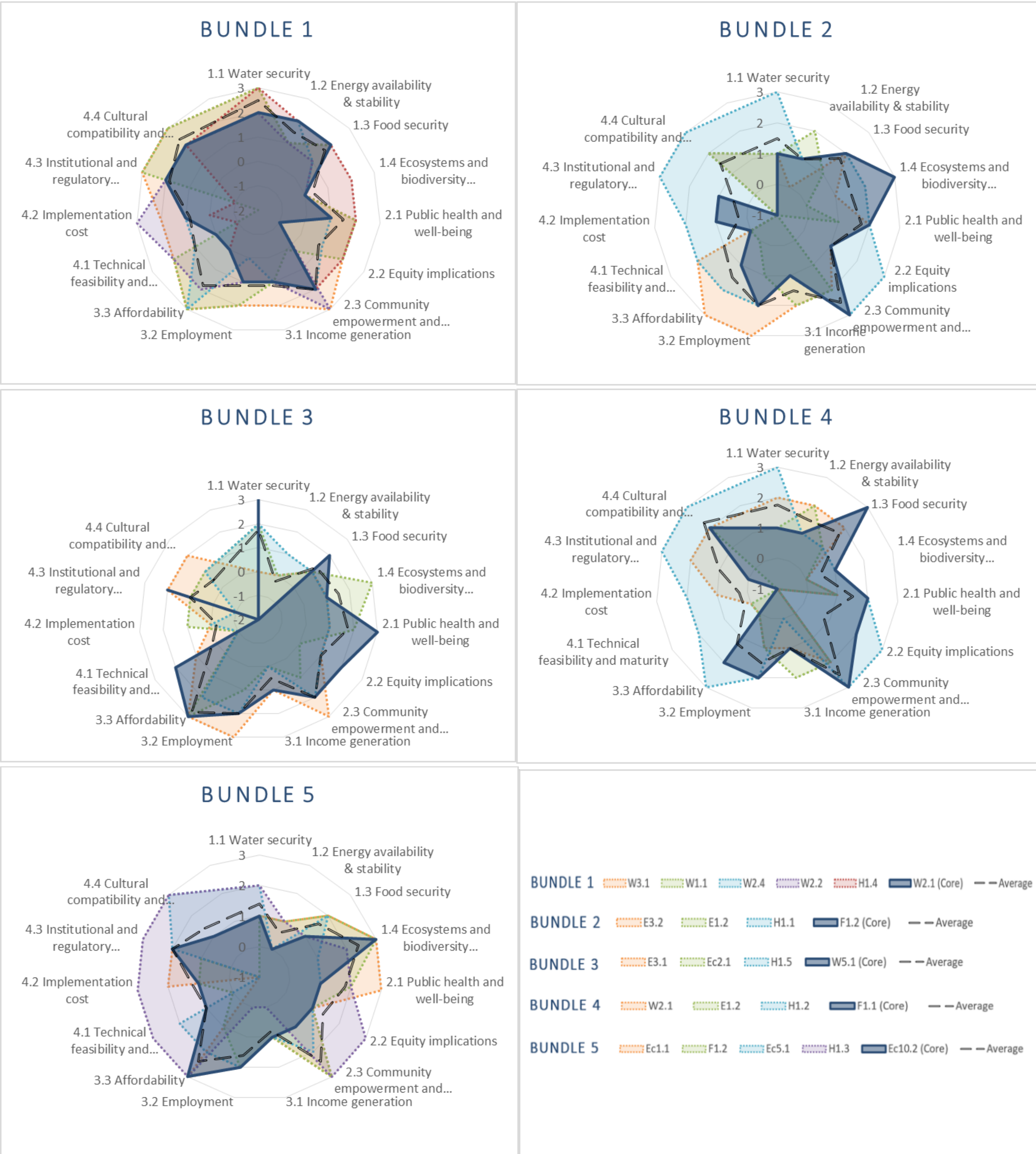


Figure 7. Graphical illustration of the performance of the bundles compared to the initial core measures

These findings confirm the value of bundling as a strategy to overcome individual measure limitations and enhance systemic impact. Furthermore, the spider graphs offer a communicative device to visualize synergies and trade-offs, supporting the development of shared understanding among stakeholders in participatory planning processes.

The New Agricultural Transformation Strategy

6. The New Agricultural Transformation Strategy

The participatory MCDA process identified a subset of WEFE measures that consistently perform well across sustainability dimensions, stakeholder preferences and robustness tests. However, the purpose of the EcoFuture strategicanalysis to articulate various measures and interventions to a coherent transformation pathway for the Jordan Valley. To this end, the robust top-performing group of measures is synthesised into the Agricultural Transformation Strategy (ATS) for Jordan and Palestine. The ATS represents a strategic shift in the way agricultural development, resource management and ecosystem stewardship are conceived and implemented in the Jordan Valley.

Rather than intensifying existing practices through increased inputs and centralised infrastructure, the ATS is based on an integrated, regenerative and resource-conscious paradigm aligned with the WEFE nexus. It responds directly to the baseline challenges identified in Section 2.1 and reframes agriculture as a leverage point for reducing systemic pressures across water, energy, food and ecosystems.

Strategic rationale

Agriculture lies at the heart of the Jordan Valley's socio-economic system and is simultaneously the sector most exposed to water scarcity, climate change, land degradation, and ecosystem decline. As such, agricultural practices act as both drivers of vulnerability and leverage points for systemic change.

The ATS is grounded in three interrelated premises:

- **Agricultural transformation is essential for WEFE security**: Improvements in water, food, energy security, and ecosystem health are deeply interdependent. Addressing them in isolation risks shifting pressures across sectors rather than reducing them. Agriculture offers a strategic entry point for simultaneously improving all WEFE pillars.
- **Incremental optimisation is insufficient under current conditions**: The baseline analysis demonstrates that existing agricultural and water management paradigms (centered on large-scale grey infrastructure, linear resource use and limited community capacities) are unlikely to deliver sustainable outcomes under climate and geopolitical stress. A qualitative shift in practices, governance, incentives and support is required.
- **Nature-based and regenerative approaches offer high leverage under uncertainty**: Measures that work with natural processes, reduce resource demand, and enhance ecosystem services tend to be more adaptable, less capital-intensive and more resilient under uncertain future conditions. These characteristics make them particularly suitable for the Jordan Valley context.

Core characteristics of the ATS

The Agricultural Transformation Strategy is defined by a set of interlinked characteristics that distinguish it from conventional agricultural development approaches:

- **WEFE integration**: Interventions are selected and designed to generate synergies across water, energy, food and ecosystems, rather than optimising single-sector performance.
- **Regenerative and nature-based orientation**: Priority is given to measures that restore soil fertility, enhance biodiversity, improve water retention and support ecosystem functioning — such as agro-ecological, permaculture-based and NBS solutions.
- **Demand-side efficiency**: Reducing losses, improving efficiency and managing demand are emphasised
- **Circularity**: circular economy principles are applied to recover nutrients from organic residues and wastewater, closing local resource loops.

- **Decentralisation and local adaptability**: Measures are compatible with small-scale farming systems, including renewable and locally managed energy solutions, and can be adapted to diverse local conditions, enhancing sufficiency and resilience to external shocks.
- **Socio-economic inclusion**: The strategy explicitly considers affordability, farmer income, community empowerment and capacity building as integral components of sustainability.

These characteristics reflect both the MCDA outcomes and stakeholder priorities expressed during the Transnational Living Lab. They represent design principles that are subsequently tested trough impact analysis, SWOT assessment and governance feasibility.

Key areas and measures

The prioritized measures emerging from the MCDA process were complemented with strategically necessary measures to form a coherent strategy structured around the following key areas. While all measures have co-benefits across different sectors, they may be classified in the following broad categories. The complete description of the measures is available in Appendix A.

Water security and efficiency:

- Smart leak detection and repair (W1.1)
- Soil-moisture monitoring and smart irrigation systems (W2.1–W2.2)
- Enhancing soil coverage to conserve moisture (W2.3)
- Improving pressure uniformity in irrigation systems (W2.4)
- Rainwater harvesting from greenhouses (W3.1)
- Desalination of brackish groundwater using solar power (W4.1)

Circular resource recovery:

- Decentralized wastewater treatment and reuse (W5.1)
- Biomass and organic waste collection (E3.1)

Renewable energy integration:

- Integrated systems for water and energy management (E1.1)
- Sustainable energy practices in agriculture (E2.1)

Agro-ecological regeneration:

- Carbon addition through compost and biochar (F1.1)
- Permaculture and agroforestry practices (F1.2)

Ecosystem restoration and biodiversity enhancement:

- Nature-inclusive agriculture and hedgerows for habitat creation (Ec1.1–Ec1.2)
- Terracing, erosion control, and protected-area management (Ec5.1, Ec10.2)

These interventions span all interdependent WEFE domains and collectively operationalize the WEFE nexus.

The following sections build on this strategic core by examining the expected impacts of the ATS, its strengths and vulnerabilities (SWOT) and the concrete actions required to translate it into practice (governance reforms, implementation pathways and enabling conditions).

6.1. Impacts of the ATS

This section synthesises the expected and observed impacts of selected priority measures within the Agricultural Transformation Strategy for Jordan and Palestine, drawing on modelling work, pilot demonstrations and stakeholder deliberations conducted within the EcoFuture project. The objective is to characterise the direction, magnitude and systemic relevance of impacts across the WEFE nexus and to clarify why the ATS constitutes a credible transformation pathway under conditions of water scarcity and climate stress. The analysis supports the foresight function of the deliverable by highlighting key co-benefits, trade-offs and leverage points, and by providing an analytical basis for the subsequent SWOT and governance analysis.

Detailed modelling outputs and techno-economic parameters are presented in Appendix G.

- **Water efficiency and smart irrigation (W2.1 and W2.2)**

Pilot demonstrations conducted by NARC under the EcoFuture project combined soil-moisture monitoring, smart irrigation control, soil fertility improvement with organic matter addition, rainwater harvesting and deionised groundwater use in greenhouse tomato production. Details can be found in the EcoFuture Deliverable D5.2. Monitoring and modelling results indicate that conventional irrigation practices substantially exceed crop evapotranspiration requirements, with 40–53% of applied water percolating below the root zone and thus remaining unavailable for plant uptake.

Using soil-moisture data and HYDRUS-1D modelling, actual crop water use was estimated at 90–170 m^3/dunum, corresponding to up to 29–41% reductions compared to conventional irrigation rates and well below the 400 m^3/dunum commonly recommended in advisory guidelines (Mazahreh, 2001). These results are consistent with findings from comparable Mediterranean contexts (Lilli et al., 2023a and b).

Techno-economic analysis (Appendix G.1) confirms that scaling up smart irrigation across the Jordan Valley is technically feasible and economically justified through a hybrid approach combining satellite-based irrigation water accounting with targeted field instrumentation. Valley-wide deployment in the Jordanian section could be achieved with approximately 15 data gateways and instrumentation of around 150 representative farms, supported by a central data platform and advisory service hosted at NARC, at an estimated capital cost of ~€0.42 million and annual operation and maintenance costs of ~€0.13 million.

Farm-level investment appraisal shows positive net present values over a 10-year horizon, but indicates that public co-financing of approximately 60% of equipment costs is required under current irrigation water pricing to ensure adoption. From a societal perspective, the measure generates net welfare gains, as the economic value of water savings and productivity improvements outweighs public support costs, particularly when accounting for water scarcity and environmental values, confirming smart irrigation as a low-regret, high-leverage intervention for improving water efficiency at scale.

- **Rainwater harvesting from greenhouses (W3.1)**

Pilot implementation of rainwater harvesting from plastic greenhouses demonstrated capture efficiencies of approximately 70%, even during a dry hydrological year. When extrapolated to the current and projected number of greenhouses in the Jordan Valley, rainwater harvesting alone could supply 6–10 million m^3 of water annually in the Jordanian part of the Valley.

Techno-economic analysis (Appendix G.2) indicates that rainwater harvesting from greenhouses requires substantial public co-financing to be adopted at scale under current irrigation water pricing, with subsidies of approximately 95% of investment costs needed to ensure farm-level viability. From a system perspective, the measure generates positive social welfare when the full scarcity and environmental value of water is considered, while lower water valuation assumptions result in welfare losses. Despite this, rainwater harvesting remains a strategically relevant early-phase stabilisation measure, as it delivers large, visible volumes of non-conventional water, reduces pressure on groundwater resources, enhances local water autonomy, and creates enabling conditions for wider transition toward water-efficient and regenerative practices.

- **Soil fertility improvement with organic matter addition (E3.1 and F1.1)**

Organic matter addition through compost and biochar application showed substantial productivity and water-retention benefits. In the Jordanian pilot, tomato yields increased from approximately 6 to 9 t/dunum, while comparative evidence from the region and other Mediterranean contexts demonstrates a strong positive relationship between soil organic carbon content and maximum crop yield.

The soil organic carbon in Deir Alla and the JV is 0.8 % or less and in the other experiments in Crete is 1.5 and 2.8% respectively. The maximum tomato yield increases from 6.5 tons/dunum (0.8% organic carbon) to 8 tons/dunum (1.5% organic carbon) to almost 21 tn/dunum (2.8% organic carbon). The increase in soil carbon relates directly to higher productivity and soil health.

Beyond yield effects, increases in soil organic carbon significantly enhance soil moisture capacity. Modelling based on carbon-sensitive pedotransfer functions suggests that a 1% increase in soil organic carbon can increase plant-available water content by approximately 35 m^3/ha. When scaled to cultivated areas, this translates into potential annual water-saving effects of approximately 7 million m^3 in Jordan and 4 million m^3 in Palestine, by delaying irrigation onset and reducing irrigation frequency.

These results highlight soil restoration as a dual-benefit intervention, simultaneously improving food productivity and water security.

- **Decentralized wastewater treatment and reuse (W5.1)**

Pilot demonstrations conducted under the EcoFuture project in Palestine confirm the technical feasibility and strategic relevance of decentralised, solar-powered wastewater treatment and reuse systems for agricultural irrigation in the Jordan Valley. The Marj Naje pilot, serving a small rural community, provides a validated reference for unit costs, treatment performance and operational requirements under local conditions.

Building on this pilot, a scale-up analysis (included in Deliverable 5.2 and summarized in Appendix G.4) focuses on rural villages and small communities in the Palestinian Jordan Valley —excluding Jericho, which is already served by a centralised facility. The analysis indicates that decentralised systems could supply approximately 2 million m^3 of treated wastewater per year, corresponding to about 10% of current irrigation water demand. This volume represents a strategically significant non-conventional water source that can be reused for agriculture and landscape irrigation, directly reducing pressure on groundwater abstraction and purchased water.

The decentralised and modular nature of the system (combining local sewer networks with compact treatment units powered by solar energy) makes it particularly suitable for the Palestinian context, where dispersed settlements, infrastructure constraints and political conditions limit the feasibility of large centralised solutions. Scaling such systems across the rural Jordan Valley would also substantially reduce environmental and public health risks associated with cesspits, while enabling nutrient recovery and improved water quality management.

Indicative cost scaling based on the Marj Naje pilot suggests that providing decentralised wastewater treatment and reuse services to most rural communities in the Palestinian Jordan Valley would require investment on the order of tens of millions of USD, with opportunities for cost reduction through modular scaling, clustering of villages and declining technology costs. From a foresight perspective, decentralised wastewater reuse constitutes a high-impact, politically resilient and systemically enabling intervention, supporting agricultural resilience, water security and circular resource management under conditions of long-term uncertainty.

- **Circular management of organic resources (E3.1)**

Material flow analysis using the Bio-residue/Excreta calculator (Bio-REX) tool indicates that, in the Jordanian part of the Valley, available organic residues and livestock excreta could fully cover nitrogen, phosphorus and potassium fertilisation needs. In the Palestinian context, recycling potential fully covers nitrogen demand and partially covers phosphorus and potassium needs.

This suggests that circular biomass management can significantly reduce dependence on imported fertilisers, enhance soil fertility and support the regenerative orientation of the ATS, while contributing to waste reduction and nutrient pollution control. Details can be found in the EcoFuture Deliverable D3.4.

- **Renewable energy integration in agriculture**

Solar energy deployment (29.7kWp installed capacity) at NARC's Deir Alla Agricultural Research Station demonstrated annual savings of more than 11,000 JOD per year (25%) in total electricity consumption, supporting progress towards energy autonomy and emission reduction in agricultural operations.

At system level, renewable energy integration strengthens the viability of water-saving and reuse measures by decoupling resource efficiency from energy cost escalation, reinforcing WEFE synergies.

- **Combined system-level impacts**

When combined, the priority water-security and efficiency measures promoted by the ATS yield transformative system-level effects. In the Jordanian part of the Valley, rainwater harvesting, soil organic matter restoration and smart irrigation together could enable greenhouse irrigation largely through harvested and blended water sources, substantially enhancing water security.

  - Greenhouse water harvesting = 6-10 M m3/yr
  - 1% increase in organic matter = 7 M m3/yr
  - Smart irrigation ➔ 29-41% reduction in irrigation rate

In the Palestinian part, the combination of rainwater harvesting, soil restoration, decentralised wastewater reuse and smart irrigation could reduce groundwater abstraction by more than 50%, slowing aquifer depletion and improving long-term resilience.

  - Greenhouse water harvesting = 1 M m3/yr
  - 1% increase in organic matter = 4 M m3/yr
  - Wastewater reuse = 5 M m3/yr
  - Smart irrigation ➔ 29-41% reduction in irrigation rate

These combined effects illustrate the added value of a strategic, integrated approach, as isolated measures would not achieve comparable outcomes.

It is clear from the quantification of the impacts of few of the measures that the new Agricultural Transformation Strategy if implemented, would guide Jordan Valley towards resource security, environmental sustainability and people's wellbeing.

Table 13. Summary of expected system-level impacts of the Agricultural Transformation Strategy. Quantitative estimates are indicative and based on pilot demonstrations, modelling and scaling assumptions. Detailed techno-economic analyses are provided in Appendix G.

ATS intervention cluster	Water impacts	Food & productivity impacts	Energy impacts	Ecosystem & climate impacts	Systemic relevance
Smart irrigation & water efficiency	29-41% reduction in irrigation water use at field level; significant reduction in percolation losses	Maintains or improves yields through better matching of supply to crop demand	Indirect energy savings through reduced pumping	Reduced pressure on aquifers; lower salinisation risk	Low-regret stabilisation measure with positive system-level welfare, enabling wider transition
Rainwater harvesting from greenhouses	~6–10 Mm³/yr potential in Jordan Valley (JO); reduced dependence on groundwater	Increased reliability of irrigation supply	Very low energy demand	Reduced runoff; improved local water buffering	Rapid, visible gains; early stabilisation measure justified under high water scarcity and strong farmer acceptance
Soil organic matter restoration (compost, biochar)	Increased soil water retention (~35 m³/ha per +1% SOC); delayed irrigation onset	Yield increases (e.g. tomatoes from ~6 to ~9 t/dunum in pilots)	Neutral to positive (reduced irrigation frequency)	Carbon sequestration; improved soil health & biodiversity	Dual water–food leverage point; core regenerative measure
Decentralised wastewater treatment & reuse	~5 Mm³/yr reuse potential (PA); ~10% of irrigation demand	Stable water supply for agriculture	Solar-powered systems reduce operating energy	Reduced pollution loads; nutrient recycling	Strategic under constrained infrastructure contexts
Circular organic resource management	Indirect water savings via improved soils	Nutrient self-sufficiency (full NPK coverage in JO; N in PA)	Reduced energy embedded in fertilisers	Reduced waste; improved nutrient cycling	Strong circular economy co-benefits
Renewable energy integration	Enables water measures under rising energy costs	Improves economic viability of irrigation	~25% electricity savings in pilots	Emission reduction	Cross-cutting WEFE enabler

6.2. SWOT analysis of the ATS

Drawing from the findings of all the earlier phases of the project, including deliberation with regional stakeholders during two TLLs in Jordan, the SWOT analysis assesses the robustness, vulnerabilities and strategic positioning of the ATS under current and anticipated future conditions in the Jordan Valley. It is explicitly foresight-oriented, examining how the internal characteristics of the ATS interact with external drivers, uncertainties and constraints. This analysis supports strategic decision-making by informing the subsequent design of governance actions, implementation pathways and enablers for systemic transition.

Strengths: internal sources of robustness

The ATS exhibits several strengths that enhance its robustness under uncertainty.

- **WEFE nexus integration**: The strategy is explicitly designed to generate synergies across water, energy, food and ecosystems, reducing the risk of problem shifting and increasing systemic efficiency.
- **Emphasis on regenerative and nature-based solutions**: By working with natural processes, the ATS relies on measures that are inherently adaptable, often low-regret, and less sensitive to future climate variability than input-intensive alternatives.
- **Demand-side and decentralised orientation**: Prioritising water-use efficiency, loss reduction and decentralised solutions reduces dependence on large-scale infrastructure and centralised systems that are vulnerable to institutional, financial, or geopolitical disruptions.
- **Adaptability and scalability**: Most interventions are modular, thus suitable for both smallholders and larger farms.
- **Participatory and evidence-based foundation**: The strategy is grounded in participatory MCDA, pilot experience and modelling, enhancing its legitimacy, transparency, and acceptability among stakeholders.
- **Alignment with regional and international policy frameworks**: The ATS is consistent with WEFE nexus principles, climate adaptation objectives and nature-based solution frameworks, facilitating access to policy support and financing
- **Institutional anchoring in national research capacity:** Research centers such as **NARC (Jordan)** and **PARC (Palestine)** with expertise to empirically demonstrated biophysical benefits and networks supporting innovation, monitoring, and training. Living Lab participants viewed these institutions as **bridges between science, farmers and policy.**
- **Shared regional priorities:** Stakeholders from both countries recognized the **common challenges and aspirations** of the Jordan Valley, laying a foundation for long-term cooperation even under current geopolitical constraints.
- **Low-regret investment profile:** Many ATS measures deliver benefits even under pessimistic climate and political scenarios, reducing the risk of maladaptation.

Weaknesses (Internal vulnerabilities and constraints)

Despite its strengths, the ATS also presents internal limitations that may affect implementation.

- **Dependence on enabling conditions**: Many measures require supportive policies, financing mechanisms, and institutional coordination, which are not yet fully in place.
- **Upfront investment and capacity requirements**: While long-term benefits are significant, initial costs and technical knowledge needs may limit adoption by smallholder farmers without targeted support.
- **Heterogeneity of measures and implementation complexity**: The diversity of interventions, while strategically valuable, increases coordination and management demands.

- **Limited immediate visibility of benefits**: Some regenerative and ecosystem-based measures deliver benefits over medium to long time horizons, which may reduce short-term political or farmer incentives.

Opportunities: external dynamics that can accelerate transformation

Several external trends and developments create favourable conditions for the ATS.

- **Rising policy alignment:** The ATS aligns with national adaptation strategies in Jordan and Palestine, and international frameworks (SDGs, UNCCD, EU Green Deal), providing strong leverage for **institutional mainstreaming and donor engagement.**
- **Regional and international funding momentum:** Stakeholders identified significant potential to mobilize **climate adaptation, circular economy, and NbS funding** from the EU, GCF and development banks.
- **Technological advancements: Improvements in sensors, data platforms, and renewable energy technologies reduce costs and** make implementation and upscaling increasingly feasible.
- **Rising awareness among farmers and communities: Increasing exposure to climate impacts is fostering openness to alternative practices and innovation.**
- **Market incentives and certification:** Eco-labeled or carbon-positive agricultural products can access niche markets and enhance farmer income.
- **Emerging private sector and entrepreneurial interest:** Stakeholders noted a small but growing base of green start-ups and cooperatives in renewable energy, composting, and irrigation technologies that could catalyze local innovation ecosystems.

Threats (External risks and uncertainties)

The ATS faces several external threats that could constrain or derail its implementation.

- **Geopolitical instability and occupation-related constraints:** Restricted mobility, control over borders, and political volatility remain key obstacles to resource sharing, technology transfer, cross-border coordination and market access — particularly for Palestinian communities.
- **Climate extremes exceeding adaptive capacity:** Intensifying droughts, heatwaves, and soil salinization threaten the long-term viability of agricultural systems and may outpace adaptive capacity if not urgently addressed.
- **Institutional fragmentation and coordination gaps: Low inter-ministerial coordination**, overlapping mandates and lack of a unified WEFE governance framework may slow adoption of integrated approaches.
- **Fragmented funding streams:** Short project cycles, donor dependency, and lack of national budget integration risk undermining the sustainability of interventions after pilot phases.
- **Social inequality and vulnerability:** Without targeted support, smallholders and marginalized groups risk exclusion from the technological and financial benefits of the ATS.
- **Economic fragility and dependency on imports:** High energy and input prices, inflation, and limited domestic production capacity create vulnerabilities for smallholders and local authorities.
- **Limited financial instruments and business models:** Farmers and local authorities lack access to affordable credit or incentive schemes for renewable energy, circular practices, and NbS adoption. Public–private collaboration remains underdeveloped.
- **Insufficient data, monitoring and knowledge transfer:** Both countries lack **integrated databases** and data-sharing mechanisms on water, energy, and agricultural performance. Stakeholders stressed that evidence-based management is currently hindered by fragmented and outdated information.

- **Weak extension and training systems:** Farmers require ongoing technical support to adopt new practices. Extension services are under-resourced and disconnected from research institutions.

Strategic implications for foresight and implementation

The foresight-framed SWOT highlights that the ATS is structurally robust, but implementation-sensitive. Its success depends less on the intrinsic validity of the strategy and more on the ability to create and sustain enabling conditions.

Key strategic implications include:

- prioritising early, visible wins to build momentum and trust;
- sequencing measures to balance short-term benefits with long-term transformation;
- strengthening governance coordination and institutional learning;
- embedding flexibility and adaptive management into implementation pathways.

These implications directly inform the next sections of the strategic analysis, which focus on governance arrangements, operationalisation actions and systemic enablers required to operationalize the ATS.

6.3. Governance actions for operationalising the new ATS

Appendix A presents a list and description of program of measures proposed. The description of each measure contains a list of actions necessary to take for the implementation of the measures. It is clear that the implementation of most of the measures should be implemented by the farmers. This necessitates significant governance actions. This section defines the governance actions, institutional arrangements and coordination mechanisms required to operationalise the ATS in Jordan and Palestine. The SWOT analysis highlights that the ATS is structurally robust, but highly sensitive to institutional, regulatory and coordination conditions. Governance arrangements therefore are critical in aligning institutions, regulations, capacities, incentives and narratives around a shared transformation agenda.

Political buy-in and institutional endorsement of the ATS

The new Agricultural Transformation Strategy is diametrically opposite from the current modern agricultural policy. A first governance priority is to ensure that the ATS is formally recognised and endorsed by relevant public authorities, so that it is not perceived as an isolated project outcome but as a shared strategic direction.

Jordan has established the WEFE Nexus Committee, a trans-ministerial committee that aims to streamline WEFE Nexus projects and activities. The Committee is being overseen by the Ministry of Planning and coordinates activities across all related Ministries in Jordan. The EcoFuture proposed Strategic Plan for Jordan could be adapted by the WEFE Nexus Committee as a blue print for the WEFE operationalization.

Key governance actions include:

- identification of the ministries and national authorities whose formal endorsement is required for the ATS (e.g. agriculture, water, environment, energy, planning);
- clarification of whether and how the ATS should be integrated into national strategies, sectoral plans, or policy frameworks;

- identification of political and institutional champions within key ministries who can support adoption and continuity.

Formal buy-in is essential to ensure legitimacy, stability across political cycles, and alignment of public investments with the ATS objectives.

Operational agencies and coordination mechanisms

Once endorsed, the ATS requires clear assignment of implementation responsibilities.

Governance actions under this pillar include:

- mapping of ATS measures to existing operational agencies best positioned to implement them;
- identification of overlaps or gaps in institutional mandates;
- establishment of a coordination mechanism to avoid fragmentation and duplication, such as the Jordanian WEFE Nexus committee;
- assessment of capacity gaps within key agencies (e.g. extension services, research institutions) requiring reinforcement. For instance, The National Agricultural Research Center in Jordan could be the "scientific arm" of the WEFE Nexus Committee.

Funding and financing as governance instruments

Governance plays a critical role in translating strategic priorities into funding and financing pathways.

Key governance actions include:

- identification of appropriate funding sources for different categories of ATS measures (public budgets, donor funding, development finance);
- clarification of which measures should be publicly funded, co-financed, or primarily supported by private investment;
- assessment of the need for blended finance mechanisms;
- definition of incentive schemes for farmers, such as subsidies, cost-sharing arrangements, or tax exemptions.

The Strategic Plan is a necessary and valuable document for Jordan and Palestine in order to request funding from funding agencies regarding the implementation of the WEFE Nexus.

Clearing house for project results and monitoring

Effective governance requires a shared knowledge and monitoring infrastructure.

Governance actions include:

- establishment of a national WEFE knowledge and data platform acting as a clearing house for project results, pilot outcomes and monitoring data;
- identification of the most appropriate hosting institution (e.g. agricultural research centres, water authorities, ministries);
- definition of core indicators to be monitored (e.g. water savings, soil health, energy use, operation and maintenance);
- development of protocols for data sharing across ministries and agencies;

- assessment of whether the platform should evolve into a formal Monitoring & Evaluation framework.

This clearing-house function is essential for institutional learning, transparency, and adaptive governance.

Training hubs as governance-supported infrastructure

Governance actions are required to establish training as a national transition infrastructure, and to design, mandate, and anchor training hubs institutionally.

Key governance actions include:

- defining what a training hub should entail in terms of functions and scope;
- deciding where hubs should be hosted (e.g. research stations, vocational centres, cooperatives);
- prioritising training topics linked to ATS measures (e.g. smart irrigation, composting, solar pumping);
- defining governance models for training hubs (public, cooperative-led, or hybrid);
- linking training hubs to the clearing house to ensure feedback between practice and policy.

Governance differentiation across territories

While the ATS provides a shared strategic direction, governance implementation must remain territory-sensitive.

- In Jordan, governance efforts can build on relatively strong institutional capacity, focusing on coordination, scaling, and financing.
- In Palestine, governance must prioritise decentralised solutions, community-based schemes and innovative organisational models that function under access and infrastructure constraints.

Recognising these differences is essential for equitable and realistic implementation.

6.4. Operationalization actions for priority preparatory measures

While most of the measures listed in Appendix A will be implemented by farmers which requires knowledge transfer and training there is a subset of measures that require significant preparatory, coordination and capacity-building efforts prior to large-scale deployment. These measures have been identified as both high-impact and implementation-sensitive, meaning that their success depends critically on adequate preparation. The following four measure groups are addressed in detail:

1. Rainwater harvesting for protected agriculture
2. Smart irrigation and reduced water use
3. Organic matter recycling
4. Green water enhancement through soil organic matter (SOM) addition

For all other ATS measures, the level of preparation required is lower or implementation pathways are already well established. These measures are described in sufficient detail in Appendix A and are not further elaborated here.

Rainwater harvesting for protected agriculture

Rainwater harvesting from greenhouses and plastic houses represents a highly ranked and robust intervention but requires standardisation, piloting, and economic validation prior to scaling.
Key preparatory implementation steps include:

- Development of technical specifications and design standards, covering collection systems, storage options, integration with existing irrigation infrastructure, and maintenance requirements;
- Identification and selection of representative pilot areas (north, central, and south Jordan Valley) to reflect climatic, agronomic, and socio-economic diversity;
- Installation of pilot systems in collaboration with selected farmers, cooperatives, and extension services;
- Promotion and outreach activities, targeting farmers through demonstrations and advisory services to increase awareness and acceptance;
- Cost–benefit analysis, assessing investment costs, water savings, productivity effects, and payback periods under local conditions;
- Integration with complementary measures, particularly soil organic matter addition, to maximise water retention and system-level benefits.

These preparatory steps aim to reduce uncertainty, demonstrate feasibility, and create the basis for broader uptake.

Smart irrigation and reduced water use

Smart irrigation measures offer significant water-saving potential but depend on data availability, advisory capacity, and farmer trust.
Preparatory implementation steps include:

- Land-use and soil mapping, including assessment of soil texture, salinity, infiltration rates, and existing irrigation practices, to prioritise intervention areas;
- Baseline data collection, covering soil moisture dynamics, crop water requirements, and current water-use patterns;
- Deployment of distributed instrumentation, such as soil-moisture sensors and data transmitters, in pilot plots;
- Development of decision-support and advisory services, translating sensor and modelling data into actionable irrigation guidance (e.g. weekly recommendations);
- Pilot experiments, supported by modelling and satellite-based analysis (e.g. through national agricultural research institutions), to validate water savings and yield effects;
- Training and capacity building, focusing on hands-on use of monitoring tools and interpretation of recommendations.

These steps are essential to ensure that smart irrigation solutions are perceived as reliable, useful, and manageable by farmers.

Organic matter recycling

Organic matter recycling underpins both soil regeneration and circular resource use, but requires logistical coordination, institutional arrangements, and economic structuring.
Key preparatory steps include:

- Assessment of organic residue availability, including manure, crop residues, and organic waste volumes at local and regional scales;

- Design and establishment of collection and processing centres, including separation, composting, and stabilisation facilities;
- Engagement of private-sector and cooperative actors, particularly for collection, processing, and distribution;
- Definition of quality standards for compost and organic amendments to ensure agronomic effectiveness and farmer confidence;
- Economic analysis and business model development, including cost–benefit assessment and identification of viable operational structures;
- Pilot application on farms, linked to monitoring of soil health, water retention, and productivity outcomes.

These preparatory actions are necessary to move organic matter recycling from ad hoc practices to a reliable and scalable system.

Green water enhancement through soil organic matter addition

Enhancing "green water" (soil-stored water available to plants) through soil organic matter addition is a cornerstone of the ATS but its benefits need to be quantified, demonstrated, and communicated. Preparatory steps include:

- Selection of pilot areas representing different soil types and farming systems;
- Baseline soil assessments, including soil organic carbon, water-holding capacity, salinity, and structure;
- Implementation of carbon addition measures, using compost, manure, or biochar produced through local recycling schemes;
- Training of farmers on application methods, timing, and integration with irrigation practices;
- Monitoring and evaluation, focusing on changes in soil water-holding capacity, irrigation needs, crop resilience, and yield stability;
- Estimation of water-saving and productivity benefits, to support evidence-based scaling and policy support.

This preparatory work is critical to demonstrate that soil-based water retention can complement technological water-saving measures.

6.5. Enablers for systemic transition

While Sections 2.6 and 2.7 addressed the governance actions and targeted operationalisation steps required to initiate the Agricultural Transformation Strategy, this section focuses on the system-level enablers that determine whether the strategy can scale, persist, and become embedded in the socio-economic fabric of the Jordan Valley. The analysis examines the production models, organisational forms, business and market dynamics, and diversification pathways that must evolve in parallel with policy and project implementation. From a foresight perspective, these enablers shape the long-term transition pathways of the agricultural system, influencing not only the pace of change, but also the direction and durability of the transformation.

Transition to production models aligned with the ATS

A fundamental enabler for scaling the ATS is the gradual transformation of dominant agricultural production models in the Jordan Valley. Current systems are often characterised by high dependence on water and external inputs, limited resilience to climate stress, and weak integration with ecosystem processes.

The ATS promotes production models that are regenerative and agroecological, improving soil health, water retention, and ecosystem services; resource-efficient, aligning production intensity with local water and energy availability; and resilience-oriented, prioritising yield stability and risk reduction over short-term maximisation.

To operationalise transformation while managing risk, the ATS implies a sequenced transition pathway:

- Phase 1: Stabilisation Measures: Water loss reduction, smart irrigation, rainwater harvesting, and efficiency measures that deliver rapid and visible benefits.
- Phase 2: Regeneration Measures: Soil organic matter restoration, organic matter recycling, agroforestry, and ecosystem-based measures that rebuild productive capacity.
- Phase 3: Diversification and value creation Measures: Territorial branding, alternative crops, regenerative value chains, and circular agri-business models.

This sequencing reduces adoption barriers, builds trust, and aligns short-term incentives with long-term transformation. Enabling this shift requires consistent signals from policy, advisory services, and markets, as well as access to knowledge and tools that support farmers during transition phases. Without such alignment, innovative practices risk remaining confined to pilot settings.

Role of cooperatives and economies of scale

Given the predominance of smallholder farming, collective organisation is a critical systemic enabler of the ATS. Cooperatives and other collective structures play a central role in overcoming fragmentation and reducing individual risk.

Key enabling functions include:

- shared access to infrastructure (irrigation systems, composting facilities, renewable energy installations);
- economies of scale in procurement, maintenance, and service provision;
- collective access to finance, insurance, and advisory services;
- improved bargaining power in markets and value chains.

From a foresight perspective, cooperatives act as meso-level intermediaries, linking individual farmers to institutional frameworks and markets, and enabling scaling without sacrificing local adaptability.

Business models and agri-business creation

The long-term viability of the ATS depends on the emergence of business models that make regenerative and resource-efficient practices economically sustainable, and on the actors capable of implementing them.

Promising business models include:

- service-based models (e.g. irrigation-as-a-service, monitoring-as-a-service);
- circular economy models for compost, organic fertilisers, and biomass valorisation;
- renewable energy services for irrigation and farm operations;
- advisory, training, and data-driven support services linked to agroecological practices;
- encouraging agri-business creation linked to regenerative practices, agro-tourism, and circular economy activities.

These models create opportunities for new agri-businesses led by youth, cooperatives, SMEs, and local service providers. However, their emergence depends on targeted support, including business skills development and vocational training, access to incubation, mentoring, and early-stage finance, and facilitation of partnerships between research institutions, cooperatives, and private actors. From a foresight standpoint, nurturing a local agri-business ecosystem aligned with the ATS is a key condition for employment generation, innovation diffusion, and long-term economic resilience.

Marketing, value chains and territorial branding

The ability to market and valorise ATS-aligned practices products is a decisive enabler of systemic transition. Regenerative, water-efficient, and climate-positive products can only drive change if they are rewarded by markets. Addressing current market bottlenecks will enable access to higher-value market segments and strengthen farmer incentives.
Enabling conditions include:

- development of aggregation centres and cooperative-based marketing structures;
- investments in cold-chain and logistics infrastructure;
- certification and labelling schemes reflecting environmental and social performance;
- territorial branding strategies for market differentiation, linked to sustainability, quality and origin.

Alternative products and diversification pathways

Climate change and increasing water scarcity necessitate diversification towards alternative crops and products better adapted to arid and semi-arid conditions and consistent with the ATS principles. Promising alternatives may include drought- and salinity-tolerant crops, agroforestry products, and products linked to ecosystem restoration and circular resource use. Diversification will enhance adaptive capacity, income stability, and long-term resilience of the agricultural system.
Current barriers include limited farmer experience, uncertain demand and difficulties integrating new products into existing value chains. Systemic enablers therefore include:

- pilot and demonstration projects for alternative products;
- market assessments and demand analysis;
- support for integrating alternatives into existing or newly developed value chains;
- alignment with branding and certification strategies.

6.6. Conclusions

This chapter presented a comprehensive strategic analysis for Jordan and Palestine, translating the long-term vision of ECOFUTURE into a coherent and actionable transformation pathway for the Jordan Valley. The ATS articulates a qualitative shift towards an integrated, regenerative, and resource-efficient agricultural paradigm aligned with the WEFE nexus. Rather than promoting isolated measures, it defines a strategic direction capable of generating synergies across sectors while enhancing resilience under uncertainty.

The analysis of expected impacts showed that the ATS has the potential to deliver significant co-benefits across water security, food security, energy resilience, ecosystem integrity and socio-economic outcomes. At the same time, the SWOT analysis highlighted that the strategy's success depends less on its technical validity than on the enabling institutional, financial and socio-economic conditions that shape implementation pathways.

In response, the chapter outlined a layered action framework. First, governance actions were identified to ensure political endorsement, institutional coordination, funding alignment, and knowledge management, thereby enabling the transition from project-level experimentation to policy-driven implementation. Second, targeted operationalisation actions were defined for those measures requiring substantial preparatory work, ensuring early learning, risk reduction and scalability.

Finally, the analysis of system enablers and scaling-up conditions emphasised that long-term transformation hinges on changes in production models, collective organisation, business and market dynamics, and product diversification. These enablers determine whether the ATS remains a collection of successful pilots or evolves into a durable restructuring of the agricultural economy of the Jordan Valley.

Conclusions and priority actions

7. Conclusions and priority actions

The Jordan Valley, the "bread basket" of Jordan and Palestine, is already experiencing the impacts of climate change with reduced water availability, loss of soil fertility, and degradation of ecosystem services. The region is facing significant challenges related with water demand for irrigation, water and soil quality, agricultural development and renewable energy availability. The current geopolitical conflict further aggravates the critical situation, undermining the capacity to provide resource security and improve the livelihood of the people in the region.

In this context, this document presented a strategic plan for Jordan and Palestine, translating the long-term vision of ECOFUTURE into a coherent and actionable transformation pathway for the Jordan Valley. Through its three interrelated strategic goals: Resource Security, Environmental Sustainability, and Socio-Economic Prosperity, the Strategic Plan outlines a clear, actionable path forward. Developed through an integrated, participatory framework, it reflects both scientific rigor and local knowledge, ensuring that proposed solutions are feasible, context-sensitive, and equitable.

Starting from an assessment of baseline conditions and systemic challenges, the analysis demonstrated that incremental optimisation of existing agricultural and resource-management practices is insufficient under conditions of climate stress, water scarcity and institutional fragmentation. Using participatory Multi-Criteria Decision Analysis, a portfolio of robust and high-impact interventions was prioritised and synthesised into the Agricultural Transformation Strategy.

The ATS articulates a qualitative shift towards an integrated, regenerative and resource-efficient agricultural paradigm, in which agriculture becomes a leverage point for improving water, energy, food and ecosystem sustainability simultaneously. The analysis of impacts confirms that this strategy can generate substantial co-benefits across WEFE domains, while the SWOT analysis highlights that its success depends primarily on governance alignment, sequencing of actions and enabling socio-economic conditions.

The foresight perspective shows that implementation sensitivity, rather than technical uncertainty, constitutes the main risk. Early, visible gains are needed to build trust and momentum, while longer-term regenerative and diversification measures must be embedded through appropriate governance, financing and market structures. The following priority actions turn key insights into concise and actionable directions. These actions will help operationalize the proposed paradigm, enabling the Jordan Valley to not only address desertification but to also serve as a regional model for integrated, climate-adaptive development.

7.1. Priority actions for Jordan

1. Endorse the ATS as a guiding framework for WEFE operationalisation

Formally recognise the Agricultural Transformation Strategy as a reference framework for WEFE nexus implementation in the Jordan Valley, ensuring coherence across agricultural, water, energy and environmental policies and public investment programmes.

2. Prioritise demand-side water security measures

Focus short-term policy action on water loss reduction, smart irrigation, rainwater harvesting and soil-based water retention, which offer rapid, low-regret gains and reduce pressure on groundwater and surface water systems.

3. Align financing and incentives with regenerative outcomes

Redirect subsidies, grants and co-financing schemes towards practices that improve soil health, water efficiency, circular resource use and renewable energy integration, while discouraging input-intensive and water-demanding practices.

4. Strengthen WEFE nexus coordination and delivery capacity

Use existing coordination mechanisms, such as the WEFE Nexus Committee, to align ministries and operational agencies, designate lead institutions for implementation, and reinforce extension services and research centres as delivery and learning hubs.

5. Invest in training, demonstration and monitoring infrastructure

Scale up training hubs, demonstration sites and a national WEFE knowledge platform to support farmer adoption, institutional learning and adaptive management.

7.2. Priority actions for Palestine

Given the largely shared biophysical challenges and development priorities identified for the Jordanian and Palestinian parts of the Jordan Valley, the strategic orientation of the ATS is equally relevant for Palestine. At the same time, implementation priorities need to account for specific institutional, infrastructural and access-related constraints.

1. Promote decentralised and community-based WEFE solutions

Prioritise decentralised water, energy and resource-recovery systems that can operate under fragmented infrastructure and governance conditions, including community-managed schemes and cooperative-based models.

2. Scale decentralised wastewater treatment and reuse

Treat decentralised wastewater treatment and reuse as a strategic priority, enabling increased irrigation water availability, nutrient recovery and pollution reduction where centralised systems are not feasible.

3. Support regenerative and low-input farming systems

Encourage agroecological and regenerative practices that reduce dependence on imported inputs, improve soil water retention and enhance resilience to climate and market shocks.

4. Enable collective organisation and local service provision

Strengthen cooperatives, local service providers and civil-society organisations as intermediaries for access to finance, training, technologies and markets.

5. Integrate the ATS into donor and development programming

Use the ATS as a structured basis for engaging donors and development partners, ensuring that external funding supports coherent, WEFE-integrated and scalable interventions rather than isolated projects.

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Appendix A. Extensive description of the Program of Measures

Water security measures (W)

Category W1. Water loss reduction

Objective: To reduce water losses in the JV's water distribution network by utilizing advanced technological solutions for detecting leaks, damages, and inefficiencies, and implementing timely repairs and infrastructure improvements.

Measure W1.1 Technology-Driven Water Loss Detection & Infrastructure Repair

Description of measure: It will be implemented in urban areas and agricultural zones, focusing on the northern part of the valley where water infrastructure is older. The implementation involves installing smart meters and pressure sensors along the main pipelines, particularly in the Deir Alla and North Shuna districts. A rapid response team will be trained to address leaks promptly. Expected outcomes include reducing water losses by 25% within two years and improving water availability for both domestic and agricultural use. The project will be executed in collaboration with the JV Authority and local water .utilities

Measure W1.2 Reducing Water Losses in Agricultural Ponds

Description of measure: Conduct a field survey and Identification: Conduct comprehensive surveys using remote sensing and satellite imaging to identify high-loss ponds across the JV. This will involve analyzing thermal imagery to detect temperature variations indicative of high evaporation rates. Application of Mitigation Techniques:

- Install floating covers on identified high-loss ponds. These covers can be made from materials like high-density polyethylene (HDPE) or specialized fabrics designed to reduce evaporation while allowing rainfall to penetrate. Also, innovative solutions will be studied and implemented in Deir Alla at NARC research stations. On the other hand, lining ponds with impermeable materials like geomembranes or clay liners will be implemented.

Category W2. Efficient irrigation practices. Advancing Water-Saving Irrigation Practices

Objective: To enhance water efficiency in agriculture by implementing modern irrigation techniques, optimizing water distribution, and reducing evaporation losses through innovative technologies and best practices.

Measure W2.1 Installation of Soil Moisture Meters and Data Transmitters

Description of measure: - **Studying Infiltration Rates in the JV.** The study will encompass various soil types and land-use areas within the valley, providing crucial data for optimizing irrigation strategies and water conservation efforts and implementation will be included:

Collaboration with Research Institutions that specialize in soil science and hydrology. Also, identify representative locations across the JV, covering different soil types, topographies, and land-use patterns. Employ cutting-edge soil analysis methods, including:

- Double-ring infiltrometer tests for direct measurement of infiltration rates.
- Soil moisture sensors to monitor water movement through soil profiles.
- Ground-penetrating radar (GPR) for non-invasive soil structure analysis.

Data Collection and Monitoring by installing automated data logging systems at each study site to continuously record infiltration rates and related parameters, and to conduct regular field visits for manual measurements and equipment maintenance. Mapping Infiltration Patterns is essential through utilizing Geographic Information Systems (GIS) to create detailed maps of infiltration rates across the JV and integrating satellite imagery and remote sensing data to enhance spatial analysis and visualization of infiltration patterns.

-**Deploying advanced soil moisture meters across agricultural fields to track water availability and prevent over-irrigation.**

- Integrating data transmitters to provide real-time data to farmers and agricultural authorities for informed decision-making.

The implementation of soil moisture sensors and data transmission systems has shown significant benefits in arid regions. Studies have demonstrated that such systems can improve irrigation application efficiency up to 86.6%. The integration of these sensors with wireless communication and automatic irrigation systems has proven effective in optimizing water use. Each group of farms will be connected to the same platform based on distance; regulations are needed for sharing collected data.

Measure W2.2 Development of a Mobile Application for Smart Irrigation Management

Description of measure: - **Design a user-friendly mobile application to assist farmers in monitoring soil moisture, weather forecasts, and irrigation needs**. This measure can be built upon the WAFFIR mobile application that was developed by NARC. Integration with IoT devices has shown great potential in enhancing irrigation management. The app allows farmers to remotely monitor and control irrigation systems, providing real-time data on soil moisture, weather conditions, and system performance. The integration of data analytics features can help farmers analyze historical data, predict irrigation needs, and optimize water usage and validation analysis is required to upscale the use of WFIRR mobile application.

1. Mobile Application Features:

- The app will help farmers monitor soil moisture, weather forecasts, and irrigation needs.
- This aligns with successful case studies where mobile applications integrated with IoT devices have enhanced irrigation management, allowing farmers to remotely monitor and control irrigation systems.

2. Integration of Remote Sensing Data:

-Incorporating RS climatic data for predictive irrigation recommendations is a key feature.

- This approach can significantly improve water use efficiency by providing accurate, localized weather information and crop water requirements.

3. Connection to Smart Irrigation Solutions:
- Linking the app to WAFFIR and other smart irrigation solutions for automated water-saving strategies is proposed.
-This integration can lead to substantial water savings and improved crop yields. Studies have shown that smart irrigation systems can reduce water usage by up to 30% while maintaining or improving crop productivity.

Measure W2.3 Enhancing Soil Coverage to Conserve Moisture

Description of measure: This measure includes:
-Promoting the use of organic and synthetic mulches to reduce evaporation and regulate soil temperature, and these practices will be implemented in collaboration with the municipalities.
-Encouraging cover cropping as a sustainable method to improve soil structure and water retention.

Measure W2.4 Improving Pressure Uniformity in Irrigation Systems

Description of measure: This measure involves installing pressure uniformity devices to ensure even water distribution across irrigation networks. This can significantly improve irrigation efficiency and water conservation. And applying sensors as alarming systems for non-uniform pressures in irrigation systems.

Category W3: Rainwater Harvesting for Sustainable Irrigation

Objective: To enhance water availability for irrigation by collecting and utilizing rainwater from greenhouses, reducing reliance on conventional water sources and improving water efficiency in agriculture.

Measure W3.1 Implementation of Rainwater Collection Systems

Description of measure: This measure proposes:
-Installing rain gutters on plastic house roofs to capture and direct rainwater efficiently.
-Using filtration systems to remove debris before storage.
-Implementing automated collection and distribution systems powered by solar energy and establishing roof rain-harvesting systems, the methods of water harvesting should be studied and evaluated in both macro and micro levels. Modern rainwater harvesting techniques, combined with solar-powered systems, can significantly enhance water management in arid regions. These systems reduce dependency on traditional water sources, lower operational costs, and minimize environmental impact.

Category W4: Desalination of Brackish Groundwater for Freshwater Production

Objective: To enhance water availability by desalinating brackish groundwater, producing fresh potable water while efficiently managing the extracted brine through sustainable applications.

Measure W4.1 Desalination of Brackish Groundwater

Description of measure: This measure includes:
- Utilizing solar-powered desalination units.
-Establishing cost-effective small-scale desalination plants and using innovative methods like aquaculture and algae cultivation.
Recent developments in brackish water desalination focus on improving efficiency, reducing environmental impact, and enhancing resource recovery. The integration of desalination processes with renewable energy sources, such as solar power, enhances sustainability.

Category W5: Advanced Wastewater Treatment and Reuse

Objective: To enhance water sustainability by implementing secondary and tertiary wastewater treatment processes, ensuring safe and efficient reuse of treated water for irrigation.

Measure W5.1 Implement secondary wastewater treatment to remove organic matter & tertiary treatment to further improve water quality (through filtration, disinfection, and nutrient removal), to ensure safe reuse in irrigation.

Description of measure: -Feasibility Study for Decentralized Wastewater Treatment Plants (WWTPs):
Research and evaluate various decentralized wastewater treatment technologies, with a focus on energy-efficient and low-maintenance options. These may include: Constructed wetlands (horizontal or vertical flow), Anaerobic baffled reactors, Membrane bioreactors (MBRs), Sequencing batch reactors (SBRs). **The implementation may include:** - Advanced biological treatment processes (e.g., activated sludge, membrane bioreactors)
- Filtration systems (e.g., sand filtration, membrane filtration)
- Disinfection methods (e.g., UV disinfection, chlorination)
- Nutrient removal systems to optimize water quality for agricultural use.
- Upgrade existing infrastructure such as pumps, piping, and electrical systems as necessary.
- Install real-time monitoring equipment for key water quality parameters.
- Regular sampling and testing of treated water (Comprehensive quality analysis)
- Develop sustainable strategies for managing and disposing of treatment sludge.

Energy security measures (E)

CATEGORY E.1: ADVANCING SOLAR ENERGY TECHNOLOGIES FOR SUSTAINABLE WATER AND ENERGY MANAGEMENT

Objective: To enhance energy efficiency and sustainability by deploying solar energy technologies, including ground-mounted photovoltaic (PV) systems, and agri-photovoltaics, while integrating innovative solutions for water and energy management.

Measure E 1.1 Integrated Systems for Water and Energy Management

Description of measure: 1. Solar-Powered Water Pumps Installation: o Conduct a survey of existing water pumping stations in the JV to identify suitable locations for solar-powered upgrades. (pump capacity, electric efficiency, type of water source, location, slope). small-scale farms, in Deir Alla, plastic house based-farms (5 farms)

o Design and install photovoltaic systems tailored to the energy requirements of each pumping station.

o Implement energy storage solutions to ensure continuous operation during non-sunlight hours.

2. Real-Time Monitoring Systems:

- Deploy advanced sensors and IoT devices throughout the water distribution network to monitor water flow, pressure, and quality in real-time.
- Install smart energy meters to track power consumption at pumping stations and other key points in the water system.
- Develop a centralized data management platform to collect, analyze, and visualize data from all sensors and meters.

3. Integrated Control Systems: (Data BanK, open source to local stakeholders)

- Implement smart control systems that can automatically adjust pump operations based on real-time data on water demand, energy availability, and system efficiency.
- Develop algorithms for optimizing pump schedules to maximize the use of solar energy and minimize overall energy consumption.

Measure E 1.2 Adoption of Agrivoltaics for Sustainable Agriculture

Description of measure: 1. Site Selection and Feasibility Studies:

- Identify suitable agricultural areas in the JV for agrivoltaic implementation, considering factors such as crop types, solar radiation levels, and existing infrastructure. (Determine the type of agrivoltaic systems) availability, affordability, feasibility.
- Conduct detailed feasibility studies to assess the potential energy generation and agricultural productivity under agrivoltaic systems.

2. System Design and Installation:

- Design agrivoltaic systems that optimize both solar energy generation and crop growth, considering factors such as panel height, spacing, and orientation.
- Install solar panels with adjustable tilt and spacing to allow for different crop requirements and seasonal variations.

- Implement rainwater harvesting systems integrated with the solar panel structures to maximize water efficiency.

3. Crop Selection and Adaptation: Identify and select crops that are well-suited to partial shading conditions created by solar panels.

- Develop and implement modified agricultural practices adapted to the agrivoltaic environment.

4. Monitoring: Establish comprehensive monitoring systems to track energy production, crop yields, water use efficiency, and microclimate conditions under the agrivoltaic setup.

CATEGORY E.2: IMPLEMENTING EFFICIENT ENERGY PRACTICES FOR SUSTAINABILITY

Objective: To improve energy efficiency, reduce energy loss, and integrate renewable energy solutions across key sectors such as industry, agriculture, and construction, ensuring long-term sustainability and cost-effectiveness.

Measure E 2.1 Sustainable Energy Practices in Agriculture

Description of measure: Solar-Powered Irrigation Systems:

- Assess existing irrigation systems and design solar-powered alternatives.
- Install photovoltaic panels, efficient pumps, and smart controllers for optimized irrigation.
- Provide training to farmers on operating and maintaining solar-powered irrigation systems.

Energy-Efficient Greenhouses:

- Promote the adoption of energy-efficient greenhouse designs, including proper insulation, natural ventilation systems, and energy-efficient lighting.
- Implement climate control systems that optimize energy use based on crop requirements and environmental conditions.

Precision Agriculture Technologies:

- Introduce GPS-guided tractors and farm equipment to reduce fuel consumption and improve operational efficiency.
- Implement drone technology for crop monitoring and targeted application of inputs, reducing overall energy use.

On-Farm Energy Audits:

- Conduct comprehensive energy audits of farms to identify areas of high energy consumption and opportunities for efficiency improvements.
- Develop tailored energy management plans for individual farms based on audit results.

Renewable Energy Integration:

- Assess the potential for on-farm renewable energy generation, including solar, wind, and biogas.
- Support the installation of renewable energy systems to offset farm energy costs and reduce reliance on the grid.

CATEGORY E.3: BIOMASS UTILIZATION FOR RENEWABLE ENERGY AND ORGANIC FERTILIZER PRODUCTION

Objective: To enhance sustainable waste management by collecting biomass and organic waste from agricultural residues and food waste and converting it into biogas, biofuel, and organic fertilizer, promoting a circular economy and reducing reliance on fossil fuels

Measure E 3.1 Biomass and Organic Waste Collection

Description of measure: Waste Assessment and Mapping:

- Conduct a comprehensive survey of agricultural and organic waste sources in the JV.
- Map waste generation patterns and quantities to identify optimal collection routes and processing facility locations.

Collection Infrastructure:

- Establish a network of collection points for agricultural residues and organic waste.
- Implement a fleet of specialized vehicles for efficient waste collection and transportation.

Biogas Production Facilities:

- Design and construct biogas production plants scaled to the available waste streams.
- Implement anaerobic digestion technologies suitable for the types of organic waste collected.
- Develop systems for biogas purification and storage.

Biofuel Production:

- Assess the potential for producing liquid biofuels from collected biomass.
- Implement appropriate biofuel production technologies, such as fermentation or thermochemical conversion processes.

Energy Distribution Systems: (Home biogas projects) Community introducing technologies and linking households to operating companies.

- Establish systems for distributing produced biofuels to agricultural and transportation sectors.

Monitoring and Quality Control:

- Implement systems to monitor the quality and quantity of collected waste.
- Establish quality control measures for the produced biogas and biofuels.

Measure E 3.2 Organic Fertilizer Production from Biomass Residues

Description of measure: -Utilize biogas byproduc as a nutrient-rich organic fertilizer to enhance soil fertility and reduce the use of chemical fertilizers.
-Encourage composting of agricultural residues to create high-quality soil amendments.
-Develop pilot projects for testing and scaling up biochar applications to improve soil health and carbon sequestration.

Measure E 3.3 Biogas Production

Description of measure: -Install anaerobic digesters to break down organic matter and produce biogas for electricity, heating, or vehicle fuel.

Food security measures (F)

CATEGORY F.1: IMPLEMENTING AGRO ECOLOGICAL PRACTICES FOR SUSTAINABLE AGRICULTURE

Objective: To promote agroecological practices that enhance soil health, water retention, and biodiversity while reducing dependency on chemical inputs such as fertilizers and pesticides. These practices contribute to sustainable agriculture, climate resilience, and improved long-term productivity.

Measure F 1.1 Carbon Addition for Soil Health and Climate Resilience

Description of measure: Biochar Production and Application:

- Establish local **biochar production facilitie**s using agricultural waste as feedstock.
- Conduct field trials to determine optimal biochar application rates for different soil types and crops.
- Train farmers on proper biochar application techniques and benefits.

Organic Compost Production:

- Develop community-scale composting facilities to process organic waste from farms and households.
- Implement quality control measures to ensure compost meets agricultural standards.
- Provide guidance to farmers on integrating compost into their soil management practices.

Cover Crop Implementation:

- Identify suitable cover crop species adapted to the JV's climate.
- Develop crop rotation plans that incorporate cover crops to maximize soil benefits.
- Educate farmers on cover crop management, including planting, termination, and integration with cash crops.

Soil Carbon Monitoring:

- Establish a network of soil monitoring sites across the JV. (NARC databases, NARC E-Lab)
- Implement regular soil testing to track changes in soil organic carbon levels.
- Use remote sensing and GIS technologies to map soil carbon changes at a regional scale.

Incentive Programs:

- Develop carbon credit schemes to reward farmers for increasing soil carbon sequestration
- Create certification programs for climate-resilient farming practices.

Measure F 1.2 Permaculture and Agroforestry for Sustainable Land Use

Description of measure: This measure focuses on implementing sustainable land use practices through permaculture and agroforestry:

1. Permaculture Systems: Designing integrated systems with diverse crops, trees, and livestock creates self-sustaining ecosystems.
2. Agroforestry Implementation: Planting trees alongside crops or pastures enhances biodiversity, improves soil fertility, and provides windbreaks. Agroforestry systems have shown success in semi-arid regions, with examples like the Faidherbia albida and grain systems in the Sahelian zone demonstrating increased crop yields due to improved soil conditions.
3. Silvopasture Systems: Promoting systems where livestock graze under tree canopies improves land efficiency and carbon storage.
4. Farming Polyculture: Encouraging the cultivation of multiple plant species in the same area mimics natural ecosystems and enhances resilience to pests and climate change.

Ecosystem sustainability measures (Ec)

CATEGORY EC.1: ENHANCING FARMLAND SUSTAINABILITY THROUGH NON-PRODUCTIVE LANDSCAPE ELEMENTS

Objective: To increase biodiversity, improve soil health, and enhance climate resilience by integrating non-productive landscape elements—such as hedgerows, flower strips, and buffer zones—into agricultural landscapes. These elements provide essential ecosystem services, including habitat creation, wind protection, soil erosion control, and flood risk reduction.

Measure Ec 1.1 Nature-Inclusive Agriculture (NIA) for Biodiversity and Ecosystem Services

Description of measure: This measure aims to integrate biodiversity conservation with agricultural production:

1. Preservation and Restoration of Natural Habitats: Preserving and restoring hedgerows, wetlands, and natural habitats around farmlands is crucial for supporting pollinators, birds, and beneficial insects. This approach is particularly important in the JV, where habitat fragmentation and biodiversity loss are significant challenges.
2. Buffer Zones: Maintaining buffer zones around waterways and natural landscapes helps reduce habitat destruction. In the JV context, where water quality is a concern due to agricultural runoff, these buffer zones can play a vital role in protecting aquatic ecosystems.
3. Low-Impact Grazing and Regenerative Farming: Implementing these practices enhances soil structure, biodiversity, and water retention. Regenerative practices have shown potential to increase productivity by up to 30% without further deforestation.
4. Wildflower Strips and Biodiversity Corridors: Promoting these features encourages natural pest control and ecosystem balance. In the JV's agricultural landscape, these corridors can significantly enhance connectivity between fragmented habitats, supporting overall ecosystem health.

Measure Ec 1.2 Integrating Hedgerows and Flower Strips for Biodiversity and Habitat Creation

Description of measure: This measure focuses on creating specific habitats to support biodiversity:

1. Establish hedgerows (shrubs and trees) along field edges to provide shelter for pollinators, birds, and beneficial insects. In the arid climate of the JV, selecting drought-tolerant native species for hedgerows is crucial for their survival and effectiveness.
2. Introduce flower strips with native wildflowers to attract pollinators and natural pest predators, enhancing biological control. Research suggests using drought-tolerant varieties like milkweeds (Asclepias spp.) and other native perennials that support a wide range of pollinators in arid environments.
3. Maintain and restore grass margins, and wetland areas within farmlands to improve biodiversity and water retention. This practice is particularly important in the JV, where water conservation is a critical concern.

4. Promote buffer zones around waterways to prevent nutrient runoff and protect aquatic ecosystems. Given the challenges of water quality in the JV, implementing buffer zones aligns with the broader goal of improving water management in the region.

CATEGORY EC.2: PHYTOREMEDIATION FOR WATER AND SOIL RESTORATION

Objective: To Enhance water and soil quality in the JV by implementing phytoremediation techniques that utilize plants and soil microorganisms to reduce contaminant concentrations, mitigate toxic effects, and prevent further pollution.

Measure Ec 2.1 Implement phytoremediation in contaminated sites.

Description of measure: 1. Site Assessment and Characterization:

- Conduct comprehensive surveys to identify and characterize contaminated sites in the JV.
- Analyze soil and water samples to determine the types and levels of contaminants

2. Plant Species Selection:

- Research and select plant species native to the region that are effective in removing or stabilizing specific contaminants.
- Consider factors such as climate adaptability, growth rate, and root depth in plant selection.

3. Pilot Studies:

- Implement small-scale pilot projects at selected contaminated sites to test the effectiveness of different phytoremediation approaches.
- Monitor plant growth, contaminant uptake, and environmental impacts over time.

4. Full-Scale Implementation:

- Based on pilot study results, design and implement full-scale phytoremediation projects at priority contaminated sites.
- Develop planting and maintenance protocols tailored to each site's specific conditions.

5. Monitoring and Evaluation:

- Establish a comprehensive monitoring program to track contaminant levels, plant health, and overall ecosystem recovery.
- Use advanced analytical techniques to assess the effectiveness of phytoremediation over time.

6. Biomass Management:

- Develop protocols for safe harvesting and disposal of plants that have accumulated contaminants.
- Explore potential uses for harvested biomass, such as bioenergy production or safe composting methods.

Category Ec.3: Establishment of Biomass Buffer Strips for Water and Soil Conservation

Objective: To Enhance water and soil quality in the JV by implementing biomass buffer strips composed of trees, shrubs, and perennial grasses. These natural buffers will help absorb water, reduce runoff and flooding, prevent soil erosion, and filter pollutants before they reach water bodies.

Measure Ec 3.1 Plant riparian Buffer Strips

Description of measure: Establish vegetation buffers along field margins, riparian zones, and erosion-prone areas to act as natural filters and stabilizers.
-Use deep-rooted trees and shrubs to support soil, while perennial grasses enhance surface water absorption and sediment retention.
-Perennial Grasses: These enhance surface water absorption and sediment retention. The use of native, drought-tolerant grass species is recommended for the JV's arid climate.

Category Ec.4: Fencing for Biodiversity Conservation and Landscape Connectivity

Objective: To Enhance biodiversity conservation by strategically installing fencing to protect and restore habitats for native species. This measure aims to reduce habitat fragmentation, prevent human and livestock encroachment in sensitive areas, and increase ecological connectivity across the landscape.

Measure Ec 4.1 Install and Maintain Conservation Fencing

Description of measure: Use wildlife-friendly fencing designs that allow safe movement for key species while restricting livestock and human disturbance. Research on wildlife-friendly fencing suggests using designs with a top height of no more than 40-42 inches and a bottom line height of no less than 16 inches to facilitate wildlife movement.
-Implement fencing in protected areas, ecological corridors, and buffer zones to enhance habitat restoration. This aligns with the broader goal of creating interconnected habitats in the JV, supporting biodiversity conservation efforts.

Category Ec.5: Terracing for Erosion Control and Water Quality Protection

Objective: To implement terracing techniques to reduce soil erosion, enhance water retention, and protect water quality. This measure will stabilize slopes, prevent sediment runoff into water bodies, and improve agricultural productivity in erosion-prone areas.

Measure Ec 5.1 Construct and Maintain Terraces

Description of measure: 1. Design contour terraces and stone walls to slow water flow, reduce soil loss, and enhance infiltration. Contour farming can reduce soil erosion by up to 50% and improve water retention by 10-15% on slopes ranging between 3% and 8%.

2. Use vegetated terraces with deep-rooted plants, shrubs, and trees to strengthen soil stability. This approach combines physical structures with vegetation, enhancing overall soil conservation and water retention in the JV's arid environment.

CATEGORY EC.6: IN-STREAM SMALL DAMS FOR SEDIMENT CONTROL IN WADIES

Objective: Construct small in-stream dams in wadies to reduce sediment transport, prevent downstream siltation, and enhance water retention. These structures will slow water flow, trap sediments, and help restore degraded waterways, contributing to improved water quality and ecosystem stability.

Measure Ec 6.1 Design and Construct Small Dams

Description of measure: Build check dams and permeable barriers that slow water flow while allowing natural groundwater recharge.
Use natural and locally sourced materials (e.g., stones, vegetation) to enhance ecological integration.

CATEGORY EC.7: ESTABLISHMENT OF CONSTRUCTED WETLANDS FOR WASTEWATER TREATMENT AND POLLUTANT REMOVAL

Objective: Develop and implement constructed wetlands to mimic natural wetland functions for wastewater treatment, effective pollutant removal, and carbon sequestration. This measure aims to enhance water quality, reduce environmental contamination, and support climate resilience in the JV by using nature-based solutions for wastewater management.

Measure Ec 7.1 Design and Construction of Constructed Wetlands - Site Identification and Planning

Description of measure: 1. Site Selection and Feasibility Studies:

- Identify suitable locations for constructed wetlands, considering factors such as land availability, topography, and proximity to wastewater sources.
- Conduct hydrological and soil studies to ensure site suitability.

2. Wetland Design:

- Design constructed wetlands tailored to local conditions and treatment requirements.
- Incorporate both surface flow and subsurface flow systems as appropriate.
- Plan for hydraulic retention time and loading rates based on wastewater characteristics.

3. Plant Species Selection:

- Choose native plant species that are effective in pollutant removal and adapted to local climate conditions.
- Consider a diverse mix of plants to enhance treatment efficiency and ecosystem services.

4. Construction and Implementation:

- Prepare the site, including excavation, lining (if necessary), and installation of inlet and outlet structures.
- Plant selected vegetation according to the design specifications.
- Implement water control structures to manage flow and water levels.

5. Monitoring and Maintenance:

- Establish a comprehensive monitoring program to track water quality parameters, plant health, and overall system performance.
- Develop and implement regular maintenance schedules, including vegetation management and sediment removal.

6. Integration with Existing Infrastructure:

- Connect constructed wetlands with existing wastewater collection systems.
- Develop protocols for managing treated water, including potential reuse for irrigation.

CATEGORY EC.8: WETLAND RESTORATION FOR ECOSYSTEM HEALTH AND WATER QUALITY IMPROVEMENT

Objective: Restore degraded wetlands to their natural state to improve ecosystem health, enhance biodiversity, increase water retention, and improve water quality. This measure aims to rehabilitate wetland habitats, reduce flood risks, and support climate resilience through the restoration of key wetland functions.

Measure Ec 8.1 Wetland restoration

Description of measure: This measure focuses on restoring existing wetlands:

1. Hydrological Function Restoration: Emphasizing the restoration of natural water flow and retention capabilities

2. Revegetation and Habitat Restoration: Focusing on re-establishing native plant communities and creating suitable habitats for local wildlife

Category Ec.9: Establishment of Ecological Corridors for Enhancing Connectivity in Terrestrial Ecosystems

Objective: Identify fragmented ecosystem sand establish ecological corridors to enhance habitat connectivity, reduce fragmentation, and promote biodiversity conservation. By connecting isolated ecosystems, this measure aims to support the movement of species, enhance ecosystem functions, and improve overall landscape resilience to human impacts and climate change.

Measure Ec 9.1 Design and Plan Ecological Corridors

Description of measure: 1. Design corridors to connect fragmented habitats and facilitate species movement across landscapes. These corridors should link protected areas, natural reserves, wildlife corridors, and other important ecosystems.

2. Plan multi-purpose corridors that integrate both biodiversity conservation and land-use sustainability (e.g., buffer zones around agricultural lands, reforestation areas).

3. Ensure that the width, length, and configuration of the corridors are sufficient to support the movement of key species and ecological processes (e.g., pollination, seed dispersal, migration).

Category Ec.10: Plan and Establish New Protected Areas or Enhance Management of Existing Protected Areas for Biodiversity Conservation

Objective: Plan and establish new protected areas or enhance the management of existing protected areas to preserve biodiversity, protect endangered species, and safeguard ecosystem services. This measure will contribute to the conservation of natural habitats, reduce human pressures on sensitive ecosystems, and promote sustainable land-use practices.

Measure Ec 10.1 Design and Establish New Protected Areas

Description of measure: This measure outlines the process for creating new protected areas:

-Conduct biodiversity assessments to identify regions of high ecological value, such as endemic species habitats, and critical ecosystems (e.g., wetlands, forests, riparian zones).

-Use GIS tools and satellite imagery to map and assess areas that are either under threat.

-Prioritize areas for protection based on biodiversity significance, ecological connectivity, and threats such as deforestation, over-exploitation, and climate change.
-Design new protected areas with clear boundaries, taking into account ecological connectivity, habitat diversity, and climate adaptation needs.
-Ensure new protected areas include a variety of habitat types (e.g., forests, wetlands, grasslands, rivers) to support a wide range of species.
-Establish management plans that detail objectives, actions, and timelines for the development, monitoring, and protection of these areas.
-Identify and secure land tenure agreements with landowners, local authorities etc to ensure the long-term protection of the areas.

Measure Ec 10.2 Enhance the Management of Existing Protected Areas

Description of measure: This measure focuses on improving the management of current protected areas:
-Update and strengthen management plans to address emerging threats such as climate change, illegal poaching, invasive species, and unsustainable land use.
-Improve monitoring and enforcement mechanisms to ensure compliance with regulations and protect biodiversity.
-Strengthen ecological restoration efforts in degraded areas within protected zones to restore natural habitats and improve ecosystem services.

Horizontal measures (H)

CATEGORY H.1: EDUCATIONAL MEASURES

Objectives:

- *to enhance the knowledge and skills of farmers and livestock breeders through comprehensive training programs,*
- *to create a continuous public awareness campaign to promote water issues,*
- *to integrate environmental education into the school curriculum at all levels.*

Measure H1.1 Professional Training of Farmers and Livestock Breeders

Description of measure: 1. Training Program Implementation: The measure involves conducting training programs for both existing farmers and newly established young farmers and agricultural cooperatives. These programs will be delivered through various formats, including courses, workshops, and online lessons, ensuring accessibility and flexibility for participants.

2. Specialized Topics: The training programs will cover a wide range of specialized topics crucial for sustainable agriculture in the JV: a) Irrigation and water conservation techniques b) Proper pesticide use c) Addressing climate change challenges d) Compliance with regulations e) Specialized programs for various production sectors.

3. Awareness-Raising Activities: The measure includes the implementation of awareness-raising activities aimed at disseminating agricultural information. These activities focus on transferring knowledge to beneficiaries regarding their professional engagement and improving the environmental performance of agricultural enterprises.

4. Information Dissemination Methods: Information will be provided through various channels: a) Exhibitions b) Meetings c) Presentations d) Printed materials e) Electronic materials.

5. Demonstration Activities: Practical demonstrations will be carried out to showcase: a) New irrigation technologies b) Improved irrigation systems c) New cultivation practices d) Crop protection techniques.

These demonstrations will take place either on farms or in other suitable locations, providing hands-on experience and visual learning opportunities.

The approach outlined in H1.1 aligns with successful practices observed in other arid regions. For instance, the use of demonstration farms has proven effective in showcasing innovative agricultural practices under local conditions, allowing both farmers and the community to observe and evaluate the effectiveness of new techniques. The inclusion of on-farm demonstrations is particularly important, as it facilitates peer-to-peer learning among farmers, which has been recognized as a highly effective method for knowledge transfer in agricultural communities

Measure H1.2 Public Awareness and Sensitization on Water Issues

Description of measure: 1. Continuous Campaign: The measure emphasizes the need for an ongoing public awareness campaign to highlight the importance of rational water resource management.

2. Regular Updates: Water users and the public will receive regular updates regarding: a) Current water balance conditions b) The necessity of implementing relevant water conservation measures

3. Information Distribution: One effective method identified for informing consumers is through the distribution of informational brochures.

4. Public Awareness Initiatives: The campaign will include various initiatives such as: a) Seminars on efficient water use b) Education on pollution prevention caused by various activities c) Promotion of recycled water usage on social media platforms.

Measure H1.3 Enhancing Environmental Programs in Primary, Secondary & Higher Education

Description of measure: 1. Dual Purpose: Short-term goal: Communicate messages on water conservation at home and water pollution prevention.

Long-term goal: Gradually change the mindset of future citizens regarding the proper use of water.

2. Educational Courses: This measure includes the implementation of educational courses to increase awareness of environmental issues and climate change.

CATEGORY H.2: RESEARCH, DEVELOPMENT AND DEMONSTRATION PROJECTS

Objectives:

- *to utilize new technologies, including the application of innovative processes,*
- *to explore new cultivation and production practices that contribute to environmental protection and climate change adaptation*
- *to assess the status and water balance of downstream ecosystems*

Measure H2.1 Pilot Measures for the Implementation of Precision Agriculture.

Description of measure: Specifically, these measures focus on the gradual adoption of environmentally friendly practices related to digital applications for input management and environmental monitoring.

Financial support can be provided within the framework of collaborations between producer groups and other stakeholders (advisors, researchers, food chain actors, and innovation brokers) to achieve the following objectives:

1) Reducing water consumption by adopting advanced irrigation systems and precision agriculture practices.

2) Lowering input costs, which results in both economic and environmental benefits (reducing the use of fertilizers and pesticides, adopting new crop varieties better suited to local soil, hydrological, and climatic conditions, and utilizing renewable energy sources to replace fossil fuels). This can be conducted also through demo sites for climate smart agriculture practices.

Measure H2.2 Installation of Monitoring Stations for different purposes.

Description of measure: This measure focuses on the installation and operation of continuous flow monitoring meters (for example continuous river flow monitoring stations downstream of dams etc.).

Monitoring river flow will contribute to assessing the status and water balance of downstream ecosystems. The monitoring results, supplementing the National Water Status Monitoring Network, can be used for the quantitative determination of key hydrological parameters of the ecological potential of the examined water systems.

Appendix B. Criteria and indicators for assessment

Categories / Criteria	Criteria's description	Indicators	Indicators' description
1. PROJECT KEY CHALLENGES & ENVIRONMENTAL SUSTAINABILITY	This criterion captures the impact of the implemented activity on the project's targeted challenges, on the ecosystem health and resource conservation.	1.1 Water security (quantity & quality)	This indicator includes water quality and quantity, and it addresses challenges relevant to the local context (e.g. water degradation & increasing water demand for irrigation).
		1.2 Energy availability & stability	This indicator captures energy availability, access, affordability, stability and reliability. While it primarily focuses on electricity, in its absence, other forms of energy for heating and cooking should also be considered.
		1.3 Food security (quantity & quality)	This indicator includes food quantity and quality, and it addresses challenges relevant to the local context (e.g. enabling conditions for agricultural development & soil quality degradation).
		1.4 Ecosystems and biodiversity conservation	This indicator includes biodiversity loss, soil quality degradation, which was defined as relevant in the local context, and environmental preservation. For the challenge of biodiversity loss this indicator assesses the extent to which biodiversity is enhanced through ecosystem improvement or restoration, ensuring a net positive impact on natural habitats and species.
2. SOCIAL EQUITY, COMMUNITY EMPOWERMENT AND WELL-BEING	This criterion captures the principles of inclusiveness and fairness in resource management, emphasising	2.1 Public health and well-being	This indicator assesses the benefits for human health and well-being through factors that are not captured by the rest of the indicators (e.g. excluding benefits to human well-being through income generation and improved access to clean resources). Human health and well-being includes both physical and mental health (MEA, 2004).
		2.2 Equity implications	This indicator assesses the fair distribution of resources and benefits, especially for marginalised groups.

Categories / Criteria	Criteria's description	Indicators	Indicators' description
	community-oriented approaches.	2.3 Community empowerment and capacity building	This indicator assesses the potential for community involvement and capacity building activities (e.g., training sessions, awareness programs, Indigenous Peoples and local communities' participation) in the implementation, operation, and monitoring of the solution.
3. ECONOMIC BENEFITS AND AFFORDABILITY	This criterion captures the economic aspects of the activity, by considering the financial gains, job creation potential and the affordability for local communities.	3.1 Income generation	This indicator assesses the extent to which additional income can be generated - either through new income sources, by enhancing productivity in existing ones or through new approaches, such as support for the local economy, cooperatives and new policy-driven economic incentives (as subsidies).
		3.2 Employment and job creation	This indicator assesses the extent of job creation and employment stability.
		3.3 Affordability	This indicator assesses the financial accessibility to the solution considering the stakeholders involved (including local communities).
4. IMPLEMENTATION AND OPERATIONAL FEASIBILITY	This criterion captures practicality, reliability, and manageability within the local scale.	4.1 Technical feasibility and maturity	This indicator assesses the level of technological readiness (TRL) for implementation and its compatibility with existing infrastructure.
		4.2 Implementation cost	This indicator assesses the implementation cost of each solution, considering the available budget and the economic conditions in the area.
		4.3 Institutional and regulatory compatibility	This indicator assesses the alignment of each solution with existing policies, regulations, and institutional frameworks, as well as the need for new regulations.
		4.4 Cultural compatibility and social acceptance	This indicator assesses the alignment with local cultural values and practices, increasing the likelihood of acceptance and sustained impact.

Appendix C. Explanation of the indicators' scoring scale

CRITERIA / Sub-criteria	Description	SCORE						
		-3	-2	-1	0	1	2	3
1. KEY CHALLENGES & ENVIRONMENTAL SUSTAINABILITY	This criterion aims to assess the impact of alternatives on Water-Energy-Food-Ecosystems (WEFE) security of supply.							
1.1 Water security (quantity & quality)	This sub-criterion includes water quality and quantity, considering challenges relevant to the local context (e.g. water degradation & increasing water demand for irrigation).	Significant and direct negative impacts hardly mitigated	Moderate or indirect negative impacts that are mitigated	Minor negative impacts that are easily mitigated	Neutral; no expected impacts in water quality or quantiy	Minor improvement of water quality or quantity	Moderate or indirect improvement of water quality or quantity	Significant and direct improvement of water quality or quantity
1.2 Energy availability & stability	This sub-criterion captures energy availability, access, affordability, stability and reliability. While it primarily focuses on electricity, in its absence, other forms of energy for heating and cooking should also be considered.	Significant and direct negative impacts hardly mitigated	Moderate or indirect negative impacts that are mitigated	Minor negative impacts that are easily mitigated	Neutral; no expected impacts in energy security	Minor improvement of energy security	Moderate or indirect improvement of energy security	Significant and direct improvement of energy security
1.3 Food security (quantity & quality)	This sub-criterion includes food quantity and quality,considering challenges relevant to the local context (e.g. enabling conditions for agricultural development & soil quality degradation).	Significant and direct negative impacts hardly mitigated	Moderate or indirect negative impacts that are mitigated	Minor negative impacts that are easily mitigated	Neutral; no expected impacts in food security	Minor improvement of food security	Moderate or indirect improvement of food security	Significant and direct improvement of food security
1.4 Ecosystems and biodiversity conservation	This sub-criterion includes biodiversity loss, soil quality degradation, which was defined as relevant in the local context, and environmental preservation. For the challenge of biodiversity loss this indicator assesses the extent to which biodiversity is enhanced through ecosystem improvement or restoration, ensuring a net positive impact on natural habitats and species.	Significant and direct disturbance to ecosystems' biodiversity	Moderate or indirect disturbance to ecosystems biodiversity	Minor and indirect disturbance to ecosystems' biodiversity	No expected impact on ecosystems' biodiversity	Minor and indirect enhancement of ecosystems' biodiversity	Moderate or indirect enhancement of ecosystems' biodiversity	Significant and direct enhancement of ecosystems' biodiversity
2. SOCIAL EQUITY, COMMUNITY EMPOWERMENT AND WELL-BEING	This criterion captures the principles of inclusiveness and fairness in resource management, emphasising human well-being and community-oriented approaches.							
2.1 Public health and well-being	This sub-criterion assesses the benefits for human health and well-being through factors that are not captured by the rest of the indicators (e.g. excluding benefits to human well-being through income generation). Human health and well-being includes both physical and mental health.	Significant direct damage on health and well-being	Direct damage on health and well-being	Indirect or minor damage on health and well-being	No expected impact on health and well-being	Minor health and well-being improvement	Moderate or indirect health and well-being improvement	Signigicant direct health and well-being improvement
2.2 Equity implications	This sub-criterion assesses the fair distribution of resources and benefits, especially for marginalised groups.	Significantly unequal distribution, benefitting only a specific group	Moderate inequality in distribution	Minor inequality	Neutral distribution; no evident impact on equity	Minor improvement in equitable distribution	Moderate improvement, benefiting a wider range of demographics	Significant positive impact on equity, especially for marginalized groups
2.3 Community empowerment and capacity building	This sub-criterion assesses the potential for community involvement and capacity building activities (e.g., training sessions, awareness programs, Indigenous Peoples and local communities' participation) in the implementation, operation, and monitoring of the solution.	No community involvement; excludes all community and indigenous participation	Minimal involvement, with little awareness or engagement	Limited community involvement; minimal training or capacity building	Neutral; no significant impact on community involvement or empowerment	Some community involvement; minor training programs or awareness initiatives	Active community involvement with structured training programs	Extensive community involvement including women and indigenous groups; strong capacity building and empowerment initiatives
3. ECONOMIC BENEFITS AND AFFORDABILITY	This criterion captures the economic aspects of the activity, by considering the financial gains, job creation potential and the affordability for local communities.							
3.1 Income generation	This sub-criterion assesses the extent to which additional income can be generated - either through new income sources, by enhancing productivity in existing ones or through new approaches, such as support for the local economy, cooperatives and new policy-driven economic incentives (as subsidies).	Significant and direct negative impact on economic activities	Direct negative impact on economic activities	Indirect negative impact on economic activities	No expected impact on economic activities	Indirect positive impact on economic activities	Direct positive impact on economic activities	Significant and direct positive impact on economic activities
3.2 Employment and job creation	This sub-criterion assesses the extent of job creation and employment stability.	Signigicant job losses with long-term negative effects on local employment	Job losses with potential negative effects on future opportunities	Minor job losses but may limit future opportunities	No expected impact on employment	The measure may create new jobs in the future	The measure will directly create new jobs - temporary	The measure will directly create new jobs - permanent
3.3 Affordability	This sub-criterion assesses the financial accessibility to the solution considering the stakeholders involved (including local communities).	Highly unaffordable; excludes most stakeholders	Unaffordable for most stakeholders	Unaffordable for many stakeholders	Affordable for certain stakeholders	Affordable for many stakeholders	Affordable for most stakeholders	Extremely affordable for all stakeholders
4. IMPLEMENTATION AND OPERATIONAL FEASIBILITY	This criterion captures practicality, reliability, and manageability of the measure within the local context.							
4.1 Technical feasibility	This sub-criterion assesses the level of maturity for implementation and its compatibility with existing infrastructure.	Studies need to be conducted.Can not integrate with existing infrastructure	Studies need to be conducted. Significant modifications to existing infrastructure	Studies need to be conducted. Requires modifications to existing infrastructure	Studies need to be conducted. Neutral; with no major obstacles	No major Studies need to be conducted. Minor improvements to infrastructure needed	Major studies have been conducted. Compatible with existing infrastructure	Fully matured. All necessary studies have already contacted, seamlessly integrates with existing systems
4.2 Implementation cost	This sub-criterion assesses the implementation cost of each solution, considering the available external funding or subsidies.	Extremely high cost	Very high cost	High cost	Moderate cost	Moderately low	Low cost	Very low cost with available funding
4.3 Institutional and regulatory compatibility	This sub-criterion assesses the alignment of each solution with existing policies, regulations, and institutional frameworks, as well as the need for new regulations.	Significant conflicts with regulations; major institutional incompatibility	Misalignment; would require adjustments to fit within regulatory frameworks	Relative misalignment; would require some adjustments to fit within regulatory frameworks	Neutral; aligns with existing policies without major issues	Relative alignment with existing policies and regulations; potential institutional support	Alignment; policy compatibility and institutional support	Full alignment; strong policy compatibility and institutional support
4.4 Cultural compatibility and social acceptance	This sub-criterion assesses the alignment with local cultural values and practices, increasing the likelihood of acceptance and sustained impact.	Significant cultural conflicts; high resistance from the community	Cultural misalignment; resistance from stakeholders	Relative cultural misalignment; potential resistance from stakeholders	Neutral; no expected cultural misalignment or resistence	Relative cultural compatibility; expected community acceptance.	Cultural compatibility; community acceptance and support.	Strong cultural alignment; high level of community support and acceptance.

Appendix D. Performance matrix

Measure code & title	Criteria & Indicators													
	1. KEY CHALLENGES & ENVIRONMENTAL SUSTAINABILITY				2. SOCIAL EQUITY, COMMUNITY EMPOWERMENT AND WELL-BEING			3. ECONOMIC BENEFITS AND AFFORDABILITY			4. IMPLEMENTATION AND OPERATIONAL FEASIBILITY			
	1.1 Water security	1.2 Energy availability & stability	1.3 Food security	1.4 Ecosystems and biodiversity conservation	2.1 Public health and well-being	2.2 Equity implications	2.3 Community empowerment and capacity building	3.1 Income generation	3.2 Employment	3.3 Affordability	4.1 Technical feasibility and maturity	4.2 Implementation cost	4.3 Institutional and regulatory compatibility	4.4 Cultural compatibility and social acceptance
W1.1 Technology-Driven Water Loss Detection & Infrastructure Repair	3	1	2	0	2	2	0	1	2	3	2	-2	3	3
W1.2 Reducing Water Losses in Agricultural Ponds	2	1	1	0	0	1	2	1	1	2	0	-1	2	2
W2.1 Installation of Soil Moisture Meters and Data Transmitters	2	2	2	0	1	-1	2	1	1	0	0	1	2	2

W2.2 Development of a Mobile Application for Smart Irrigation Management	2	1	1	0	1	-1	3	1	1	2	2	3	2	2
W2.3 Enhancing Soil Coverage to Conserve Moisture	1	1	1	1	1	0	2	0	0	2	1	2	3	3
W2.4 Improving Pressure Uniformity in Irrigation Systems	2	2	1	0	1	1	2	1	0	3	1	1	2	2
W3.1 Implementation of Rainwater Collection Systems	3	1	2	0	2	2	3	2	2	3	2	2	3	3
W4.1 Desalination of Brackish Groundwater	2	-2	2	0	2	-1	1	1	1	0	2	-2	-1	2

W5.1 Implement secondary wastewater treatment to remove organic matter & tertiary treatment to further improve water quality (through filtration, disinfection, and nutrient removal), to ensure safe reuse in irrigation	3	-2	2	1	3	2	2	1	2	3	2	-2	2	-2
E1.1 Integrated Systems for Water and Energy Management	2	2	2	0	2	-1	2	1	1	1	0	0	2	1
E1.2 Adoption of Agrivoltaics for Sustainable Agriculture	1	2	1	0	1	-1	2	2	1	0	0	-1	-1	2

E2.1 Sustainable Energy Practices in Agriculture	0	2	1	0	1	-1	2	1	1	1	0	-1	1	2
E3.1 Biomass and Organic Waste Collection	0	0	1	1	1	1	3	1	3	3	1	0	2	2
E3.2 Organic Fertilizer Production from Biomass Residues	1	0	2	1	2	1	2	2	3	3	2	-1	-1	2
E3.3 Biogas Production	0	2	1	0	1	0	2	1	1	1	0	-1	-2	0
F1.1 Carbon Addition for Soil Health and Climate Resilience	1	1	3	1	2	2	3	1	2	2	-1	-1	0	2

F1.2 Permaculture and Agroforestry for Sustainable Land Use	1	1	2	3	2	1	3	1	2	1	0	1	1	-1
Ec1.1 Nature-Inclusive Agriculture (NIA) for Biodiversity and Ecosystem Services	1	1	2	3	3	1	3	1	2	3	-1	2	2	1
Ec1.2. Integrating Hedgerows and Flower Strips for Biodiversity and Habitat Creation	1	0	1	3	2	1	1	0	1	3	-1	3	2	1
Ec2.1 Implement phytoremediation in contaminated sites	2	0	1	3	2	0	1	0	1	3	-1	1	1	1
Ec3.1 Plant riparian Buffer Strips	1	0	0	3	2	1	1	0	1	3	1	1	2	2

Ec4.1 Install and Maintain Conservation Fencing	1	0	0	3	1	1	1	0	1	3	-1	2	2	2
Ec5.1 Construct and Maintain Terraces	2	0	2	1	1	1	2	1	2	2	2	-1	2	3
Ec6.1 Design and Construct Small Dams	2	-1	1	1	1	1	0	1	2	1	-1	-2	2	2

Ec7.1 Design and Construction of Constructed Wetlands - Site Identification and Planning	1	0	0	3	1	0	0	0	2	1	-1	-1	1	0
Ec8.1 Wetland restoration	1	0	0	3	1	1	1	0	2	3	-1	1	2	2
Ec9.1 Design and Plan Ecological Corridors	1	0	0	3	1	1	0	0	1	3	-1	0	2	1

Ec10.1 Design and Establish New Protected Areas	1	0	1	3	1	1	1	2	3	3	-1	-1	2	1
Ec10.2 Enhance the Management of Existing Protected Areas	1	0	1	3	1	1	1	1	2	3	1	1	2	1
HORIZONTAL MEASURES														
H1.1 Professional Training of Farmers and Livestock Breeders	3	1	2	2	2	3	3	1	2	2	2	2	3	3
H1.2 Public Awareness and Sensitization on Water Issues	3	1	1	1	2	3	3	0	2	3	2	2	3	3

H1.3 Enhancing Environmental Programs in Primary & Secondary & Higher Education	2	1	1	2	2	3	3	0	0	3	3	3	3	3
H1.4 Pilot Measures for the Implementation of Precision Agriculture. Specifically, these measures focus on the	3	2	2	2	2	2	2	1	1	0	-1	0	-1	2
H1.5 Installation of Monitoring Stations for different purposes.	2	1	1	1	1	1	2	0	2	2	-1	0	-1	1

Appendix E. Ranking based on the WSM (including Horizontal measures)

Ranking based on the Weighted Sum Method	
H1.1 Professional Training of Farmers and Livestock Breeders	2.17
W3.1 Implementation of Rainwater Collection Systems	2.12
H1.2 Public Awareness and Sensitization on Water Issues	2.00
H1.3 Enhancing Environmental Programs in Primary & Secondary & Higher Education	1.95
Ec1.1 Nature-Inclusive Agriculture (NIA) for Biodiversity and Ecosystem Services	1.70
W1.1 Technology-Driven Water Loss Detection & Infrastructure Repair	1.59
W2.2 Development of a Mobile Application for Smart Irrigation Management	1.42
Ec5.1 Construct and Maintain Terraces	1.41
H1.4 Pilot Measures for the Implementation of Precision Agriculture.	1.39
W2.4 Improving Pressure Uniformity in Irrigation Systems	1.37
E3.2 Organic Fertilizer Production from Biomass Residues	1.36
F1.1 Carbon Addition for Soil Health and Climate Resilience	1.34
F1.2 Permaculture and Agroforestry for Sustainable Land Use	1.32
Ec10.2 Enhance the Management of Existing Protected Areas	1.29
Ec1.2. Integrating Hedgerows and Flower Strips for Biodiversity and Habitat Creation	1.24
E3.1 Biomass and Organic Waste Collection	1.23
W5.1 Implement secondary wastewater treatment to remove organic matter & tertiary treatment to further improve water quality (through filtration, disinfection, and nutrient removal), to ensure safe reuse in irrigation	1.23
W2.3 Enhancing Soil Coverage to Conserve Moisture	1.22
Ec3.1 Plant riparian Buffer Strips	1.19
Ec10.1 Design and Establish New Protected Areas	1.19
E1.1 Integrated Systems for Water and Energy Management	1.18
W2.1 Installation of Soil Moisture Meters and Data Transmitters	1.17
Ec2.1 Implement phytoremediation in contaminated sites	1.11
Ec8.1 Wetland restoration	1.07
Ec4.1 Install and Maintain Conservation Fencing	1.07
W1.2 Reducing Water Losses in Agricultural Ponds	1.02
H1.5 Installation of Monitoring Stations for different purposes.	0.95
Ec9.1 Design and Plan Ecological Corridors	0.81
E1.2 Adoption of Agrivoltaics for Sustainable Agriculture	0.76
E2.1 Sustainable Energy Practices in Agriculture	0.74
Ec6.1 Design and Construct Small Dams	0.73

W4.1 Desalination of Brackish Groundwater	0.57
E3.3 Biogas Production	0.52
Ec7.1 Design and Construction of Constructed Wetlands - Site Identification and Planning	0.52

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Appendix F. Ranking based on the Minimax method (including Horizontal measures)

Ranking based on the Minmax method	
W3.1 Implementation of Rainwater Collection Systems	1
E1.2 Adoption of Agrivoltaics for Sustainable Agriculture	2
E3.2 Organic Fertilizer Production from Biomass Residues	2
Ec10.1 Design and Establish New Protected Areas	2
W1.1 Technology-Driven Water Loss Detection & Infrastructure Repair	5
W1.2 Reducing Water Losses in Agricultural Ponds	5
W2.1 Installation of Soil Moisture Meters and Data Transmitters	5
W2.2 Development of a Mobile Application for Smart Irrigation Management	5
W2.4 Improving Pressure Uniformity in Irrigation Systems	5
E1.1 Integrated Systems for Water and Energy Management	5
F1.1 Carbon Addition for Soil Health and Climate Resilience	5
F1.2 Permaculture and Agroforestry for Sustainable Land Use	5
Ec1.1 Nature-Inclusive Agriculture (NIA) for Biodiversity and Ecosystem Services	5
Ec5.1 Construct and Maintain Terraces	5
Ec10.2 Enhance the Management of Existing Protected Areas	5
H1.1 Professional Training of Farmers and Livestock Breeders	5
H1.4 Pilot Measures for the Implementation of Precision Agriculture	5
Ec6.1 Design and Construct Small Dams	18
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Appendix G. Supporting techno-economic analyses

G.1 Smart irrigation and water efficiency

Figure G1.1. presents graphically the irrigation rates of the experiment. The irrigation rates for the water harvesting and deionized water plastic houses were 327 and 270 m³/dunum. However, based on the soil moisture meter measurements, it was observed that the soil moisture meter located at 50 cm depth (below the plant's root zone) exhibited increases in soil moisture with irrigation suggesting that a significant amount of irrigation water has percolated below the root zone and thus it is not available for transpiration. Modelling the irrigation experiments using the soil moisture with the HYDRUS 1-D model, we were able to estimate the amount of percolated water and the actual amount of evapotranspiration water used by the plants.

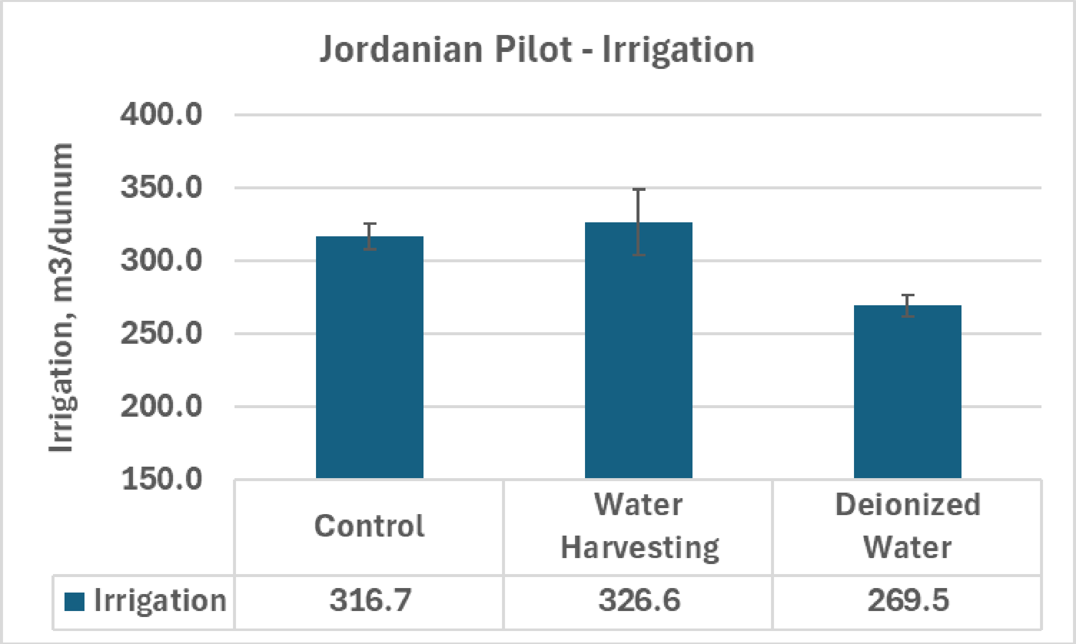

Figure G1.1. Average irrigation rates and their standard deviation of the control, water harvesting and deionized water plastic houses.

Table G1.1. presents the modelled percolation and evapotranspiration rates of the water harvesting and deionized water plastic houses experiments. The average ET rate for the water harvested plastic houses was 160 m3/dunum and for the deionized water 109 m3/dunum with the percolated water lost to be between 40 and 53% of the irrigated water. These ET rates are 51% and 34% of the irrigation rate of the control experiment (316.7 m3/dunum).

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Table G1.1. Modelled percolation and evapotranspiration rates of the water harvesting and deionized water plastic houses experiments.

m^3/dunum	WH1	WH2	RO1	RO2
Change of the water volume	1.4	-4.2	-8.9	2.0
Irrigation	343.1	249.9	164.7	277.4
Water percolated	176.6	99.4	87.9	143.4
Evapotranspiration	165.1	154.7	85.7	131.9

The irrigation rates range from 108 to 224 L per plant (1529 plants per dunum) which is the same order of magnitude to the studies conducted in Crete, Greece. Lilli et al. (2023a) and Lilli et al. (2023b) measured actual values of irrigation rates ranging between 161 to 205 L per plant, assuming 1800 plants per dunum (note this irrigation rates were actual values not corrected for any amount lost to percolation since the experiment did not monitor soil moisture). The recommended irrigation rate for plastic house tomatoes by FAO and NARC is 400 m^3/dunum (Mazahreh, 2001). Depending on the recommended irrigation rate for comparison, smart irrigation technology can reduce water use by 40%.

Table G1.2 presents the costs of implementation of smart irrigation for one plastic house. The cost of the sensors included temperature, soil moisture, salinity and pH sensors. The table presents both the cost of the EcoFuture project pilot as well as the expected cost of implementation if adapted by a farmer. The annual mixed capital and operating cost for a plastic house was estimated to 165 JOD.

Similarly, Table G1.3 presents the operating cost of the deionization unit. Assuming a 30 m^3/day water production, a a 18.000 JOD capital cost, the total water production cost (capital and operating) was estimated to be 0.126 JOD/ m^3.

Table G1.2. Costs of Implementing Smart Irrigation for One Plastic House

Item	Description	Lifetime	EcoFuture pilot site cost JOD	EcoFuture pilot site (JOD/yr)	Expected implementation Cost adopted by farmer (JOD)	Expected implementation Cost adopted by farmer (JOD/yr)	Cost type
1	Electronic valve	7 years	100	14.29	25	3.57	Capital / Fixed
2	Control panel	7 years	300	42.86	150	21.43	Capital/ Fixed
3	Internet subscription	1 year	120	120.00	120	120.00	Operating/ Annual
4	Sensors	5 years	600	120.00	100	20.00	Capital/ Fixed
Total			1120	397.15	395	164.99	Capital + operating

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Table G1.3. Cost of the deionization unit

Parameter	Value	Unit	Basis
Operating hours	10	hours per day	System working time
Flow rate	3	m³ per hour	Unit technical specification
Water production	30	m³ per day	10 × 3
Water production	900	m³ per month	30 × 30 days
Operating cost	30	JOD per month	Labor and running cost
Operating cost	0.033	JOD per m³	30 ÷ 900
Capital cost	18,000	JOD	Unit purchase cost
Lifetime	18	years	Design lifetime
Lifetime	216	months	18 × 12
Capital cost	83.33	JOD per month	18,000 ÷ 216
Capital cost	0.093	JOD per m³	83.33 ÷ 900
Total water cost	0.126	JOD per m³	Operating + capital

Scaling up smart irrigation in the Jordan Valley

Scaling up smart irrigation technology can be achieved with the use of remote sensing-based irrigation water accounting (Garrido-Rubio et al., 2020). Satellites can provide vegetation indices time series that can be used to calibrate actual evapotranpiration rates for all the crops in JV and thus extrapolate at the pixel scale the required irrigation rate on a weekly basis. In this way, only a selected number of farms that cover the crop, climatic and soil variability in the JV need to be instrumented with smart irrigation equipment and all farm plots to achieve this level of reduction in the irrigation.

At the farm scale, the measure consists of soil moisture meters measuring soil moisture at two depths (ie 20 or 30 cm and 50 or 60 cm depths) depending on the extent of the plant root system. In addition, it consists of a flow meter that measures the amount of irrigation water. Both of them collect data "real-time" and transmit them to gateways which then sends them to internet platform that the farmer can visualize the data.

The range of the gateways is usually 3-4 Km radius assuming there is no "physical obstruction" to interrupt the signal. So, the scaling up of such a system will require the following:

1. Installation of gateways along the Jordan Valley to receive the data from the soil moisture and flow meters,
2. Transmission of data (either through the internet or through sim cards) to a computer hub, and
3. A platform and geodatabase that will receive real-time data and allow the farmers to have access through their smart phones.

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Each gateway covers an area of 28 - 50 Km^2 (radius of 3-4 Km). Since the width of the Jordan Valley rarely exceeds 6 Km, gateways can be installed every 6-8 Km along the Jordan Valley. In this way with 15 gateways, the whole Jordan Valley (Jordanian section) can be covered. The cost of the gateway and its mini-solar panel with VAT is approximately 700 €. Assuming cost of installation of 100 € per gateway, the total is 12,000 €.

The data will be collected in a central computer hub. A platform will be created that would visualize the data and make it accessible to the farmers. The proposal is that this storage and platform be located at NARC. The cost of the server is 15000 € and the development of the platform about 150.000€.

It is not necessary all the farms of Jordan valley to be equipped with soil moisture and flow meters. Instead, the scaling up can be done using satellite information (Sentinel NDVI data) that can monitor the growth of the plants at a 10X10m pixel scale and perform water balance calculations on a weekly basis and estimate the amount of irrigation for each farm in the Jordan Valley. However, this would require that these estimations are calibrated for different crops using soil moisture data. This would require two full-time personnel that would automate, maintain and perform the service.

It is recommended that for each gateway, 10 farms are instrumented (total 150 farms) at a cost of 1120 JOD (~1500€) each with a total cost of 225,000 €. The cost of installation will be two people, instrumenting two farms per day at 100€/person/day. Total installation cost 15,000€

So, the capital cost for implementation of the measure is:

1. Gateways (15 * 700 €) + installation = 12,000 €
2. Server and platform development = 165,000€
3. Instrumentation cost = 225,000 €
4. Installation Cost = 15,000 €
5. Total capital cost = 417,000 €

Cost for operating the service of two people assuming 3,000 €/month would be 72,000 €/year plus the maintenance of the field equipment that is estimated at 10% of the capital cost or 42,000 €. To that is we add some other expenses of 16,000 €, the O&M cost would be 130,000 €/year.

Investment appraisal has been done at the farm level using the discounted cash flows method also considering the equipment at the valley level so that the system becomes operational for farmers to connect and exploit. Subsidy necessary for farms to break even at current irrigation fee (JOD 6.6 cents per cm) amounts at 60% of the equipment costs. Table G1.4 presents parameters along with private benefit as well as societal welfare for smart irrigation. Farmer benefit is measured in NPV (3%, 10 years) that is positive whereas water savings value and total welfare gains are calculated for both water recovery cost and full integrated environmental and scarcity cost. Welfare gains are observed in both cases, thus compensating the government spending to support the measure.

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Table G1.4 Techno-economic analysis of scaling up smart irrigation

Scaling to JV	Current (75000 GH)	Future (120000 GH)
Area (dunums)	37500	50400
Water Price to farm (JOD/m3)	0.066	0.066
Farm private benefit (NPV in M JOD)	0.92	1.45
Investment cost (M JOD)	12.37	19.41
Government spending (60% subsidy)	7.42	7.766 + 0.417
Water quantity (M m3)	5.67	8.89
Full value of water for irrigation (JOD/m3)	Min 0.53 – max 1.93	Min 0.53 – max 1.93
Water saving value (m3)	1.83 to 9.76	4.71 to 17.16
Social welfare (value of water + Private benefit-gov subsidies)	-2.38 to 6.8	3.1 to 15.57

G.2 Rainwater harvesting systems

During the winter season of (2024-2025), the 6 plastic houses captured 3 rainfall events (very dry year). The total amount of harvested water was 135 m3 with a 70% capture efficiency. There are 75000 plastic houses in the JV and they are expected to increase to 120000. Assuming an annual rainfall rate of 290 mm/year, the harvested water will range from 6.5 to 10.1 M m3/yr.

Table G2.1. Costs of Water Harvesting from One Plastic House

Item	Description	Lifetime	EcoFuture pilot site cost JOD	EcoFuture pilot site annualized cost JOD/yr	Farm cost JOD	Farm annualized cost JOD/yr	Cost type
1	Rulers on both sides 2 × 100 m	7 years	200	28.57	175	25.00	Capital/fixed
2	Zigzag wire	7 years	100	14.29	75	10.71	Capital/fixed
3	Iron sheets for gutters	7 years	500	71.43	175	25.00	Capital/fixed
4	Hose to pond	5 years	100	20.00	25	5.00	Capital/fixed
Total			900	134.29	450	65.71	Capital/fixed

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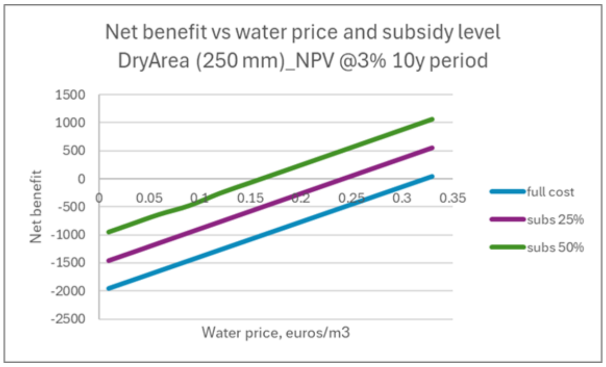
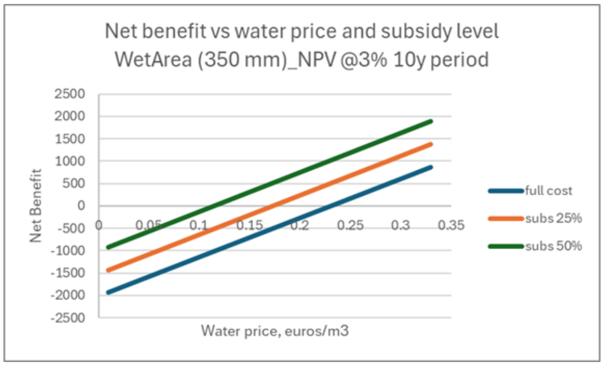


(a)



(b)

Figure G2.1. a) Capital and installation costs, b) Standard system costs (10 Plastic Houses)

Investment appraisal has been done at the farm level using the discounted cash flows method. Subsidy necessary for farms to break even at current irrigation fee (JOD 6.6 cents per cm) amounts at circa 95% of the investment costs. In table G2.2 parameters along with private benefit as well as societal welfare are presented. Farmer benefit is measured in NPV (3%, 10 years) that is slightly positive whereas water savings value and total welfare gains are calculated for both water recovery cost and full integrated environmental and scarcity cost. Welfare deadweight loss is observed in the lower water value where 2.52 M JOD is the cost for the society. Taking into account volume of water saved we can calculate the environmental efficiency of each monetary unit spent by the society that amount at 0.327 JOD per cm. Social welfare includes the value of water + Private benefit - government subsidies. Welfare gains are observed in the high water value, thus compensating the government spending in order to support the measure.

Table G2.2. Techno-economic analysis of scaling up water harvesting

Scaling to JV	**Current (75000 GH)**	**Future (120000 GH)**
Area (dunums)	37500	50400
Water Price to farm (JOD/m3)	0.066	0.066
Farm private benefit (NPV in M JOD)	1.3	2.09
Investment cost (M JOD)	63.79	96.07
Government spending (95% subsidy)	57.72	92.34
Water quantity (M m3)	7.72	12.35
Full value of water for irrigation (JOD/m3)	Min 0.53 – max 1.93	Min 0.53 – max 1.93
Water saving value (M JOD)	4.09 to 14.89	6.54 to 23.83
Social welfare	--2.52 to 8.28	-4.04 to 13.25

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G.3 Soil organic matter restoration

The results of soil fertility and yield of tomatoes in the Jordanian experiment were the following. By adding organic matter, the yield of tomatoes increased from 6.5 to 8.8 tn/dunum which is very important for the livelihood of the farmers in the area (Figure G3.1). Table G3.1 presents a comparison of maximum yield of tomato in experiments from JV and Crete with soils with different % organic carbon content. The soil organic carbon in Deir Alla and the JV is 0.8 % or less and in the other experiments in Crete is 1.5 and 2.8% respectively. The maximum tomato yield increases from 6.5 tons/dunum (0.8% organic carbon) to 8 tons/dunum (1.5% organic carbon) to almost 21tn/dunum (2.8% organic carbon). The increase in soil carbon relates directly to higher productivity and soil health.

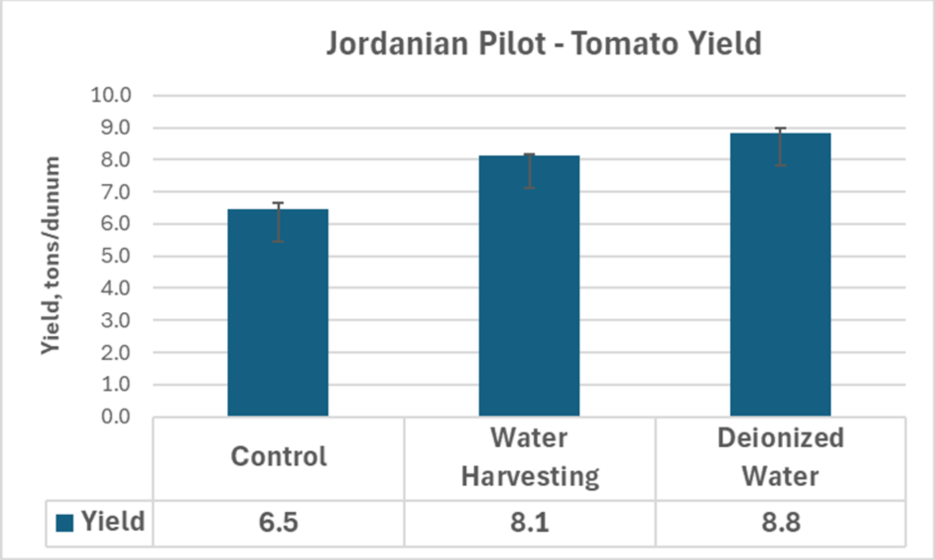

Figure G3.1. Jordanian experiment – Yield of tomatoes (tons/dunum) for the control, water harvesting and deionized water plots.

Table G3.1. Comparison of soil carbon and maximum tomato yield in different experiments

	% Soil Carbon	Max tomato yield, tn/dunum
Jordanian Pilot	0.8	6.5
Biochar Pilot (WaysTUP project)	1.5	8
SoilTrec project Pilot	2.8	21

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An additional benefit to restoring soil health by adding organic carbon to the soil is the increase in soil moisture capacity. Figure G3.2 presents estimated plant available water content using carbon sensitive pedotransfer functions (Bagnall et al., 2021) for 8 fields in Crete. Using this data, for 1% increase in soil organic carbon content, soil moisture capacity increases by 0.016 cm3/g or 35 m3/ha.

If we increase the organic carbon content by 1% in the cultivated lands of Jordan and Palestine (in the JV), the increase in available water content capacity will increase by 7 and 4 million m3 of water annual respectively. This means that the farmers can delay the onset of irrigation (because of the increase in soil moisture), saving in this way the equivalent amount of water.

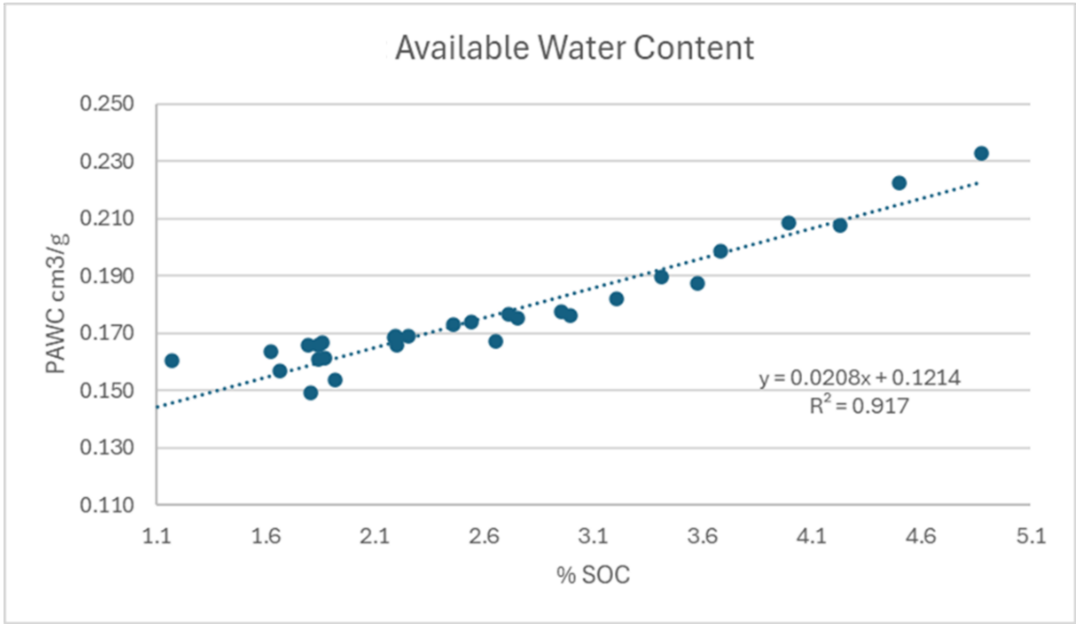

Figure G3.2. Estimated plant available water content using carbon sensitive pedotransfer functions (Bagnall et al., 2021) for 8 fields in Crete (Nexuslabs project results).

G.4 Decentralised wastewater treatment

The following are the calculations for scaling-up of decentralised wastewater treatment and reuse in the Palestinian Jordan Valley.

Baseline from the Marj Naje Pilot **-** The Marj Naje pilot serves:

- 22 households + local mosque
- Estimated population: ~145 people
- Infrastructure costs:
  - Sewer network: ~352,000 NIS
  - WWTP + solar system: ~124,000 USD
- Treatment capacity: ~20 m^3/day
- Per capita wastewater generation: ~135–140 liters/person/day

This yields a reliable reference for both cost per capita and water produced per capita under real operating conditions.

- Total Jordan Valley population (2017 census): ~60,000
- Estimated population of Jericho (excluded): ~20,000
- Target population for EcoFuture scaling: ~40,000 people[1]

Using the conservative pilot-based wastewater generation rate:

- **~0.14 m^3/person/day**

For 40,000 people:

- **Daily treated wastewater:**
  ≈ 5,600 m^3/day
- **Annual treated wastewater:**
  ≈ 2.04 million m^3/year

This volume represents a strategically significant non-conventional water source that could be reused for agriculture, fodder crops, and landscape irrigation—directly reducing pressure on groundwater and expensive purchased water.

Scaling-up Estimates

Sewer Network Costs

Pilot benchmark: 352,000 NIS for ~145 people ≈ 2,430 NIS per person
Scaled to 40,000 people: ≈ 97.2 million NIS ≈ 26–27 million USD[2]
This reflects localized sewer networks rather than long-distance trunk lines, consistent with the EcoFuture decentralized model.

Wastewater Treatment Plant Costs

Pilot benchmark: 124,000 USD for ~145 people ≈ **855 USD per person**
Scaled to 40,000 people: **≈ 34.2 million USD**

[1] This figure should be treated as an order-of-magnitude planning assumption; detailed village-by-village census verification would be required at design stage.

[2] Depending on exchange rate and terrain.

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In practice, this figure is likely conservative (overestimated), as scaling would involve[3]:

- Larger modular plants (economies of scale).
- Shared treatment units for clustered villages.
- Reduced per-capita equipment and solar costs.

Table G4.1. Total Indicative Investment Envelope[4]

Component	Estimated Cost
Sewer networks	~26–27 million USD
WWTPs + solar systems	~34 million USD
Total (order of magnitude)	**~60–62 million USD**

G.5 Circular management of organics

The potential C, N, P, K supply and demand of the two territories of the JV was estimated using the Bio-residue/Excreta calculator (Bio-REX). Bio-REX calculates the potential fertilizer demand and the biomass nutrient fluxes from the following sources: livestock excreta/manure, biosolids from wastewater treatment plants, composting of the organic fraction of municipal solid wastes and olive mill waste water (Nikolaidis, 2011). For the Jordanian part of the JV, recycling of biomass covers the N, P and K fertilization needs. More specifically, the N demand is 3,629 ton N/yr and the potential N supply is estimated at 26,013 t N/yr. Moreover, the P demand is 3,629 ton P/yr and the potential P supply is estimated at 7,208 ton P/yr. Lastly, the K demand is 3,629 ton K/yr and the potential K supply is estimated at 12,252 ton K/yr.

While for the Palestinian part of the JV, recycling of biomass covers the N fertilization needs as the N demand is 2,090 ton N/yr and the potential N supply estimated at 3,699 ton N/yr. On the contrary, recycling of biomass doesn't cover the P and K fertilization needs. More specifically, it falls short by 34% of the P needs (P demand: 1,447 ton P/yr and potential P supply: 954 ton P/yr) and 29% of the K needs (K demand: 2,573 ton K/yr and potential K supply: 1,828 ton K/yr).

Fertilizer demand in Jordan and Palestine can be satisfied by the recycling of compost and livestock excreta reducing in this way the need for imported fertilizers. Details can be found in the EcoFuture Deliverable D3.4.

G.6 Renewable energy integration

The National Agricultural Research Center of Jordan installed a 30kW solar system in the Deir Alla agricultural research station. Table G6.1 presents the techno-economic parameters of the solar system.

[3] This excludes project development and management cost (indirect costs).

[4] This estimate excludes Jericho and does not include land acquisition, major pumping stations for inter-village transfer, large-scale agricultural reuse distribution networks, or project development and management cost (indirect cost), which would be assessed in a dedicated master plan.

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The system produced 46,800 kWh in less than a year of operation and resulted in 11640 JOD in savings. Deir Alla is closer to net zero in energy. Together with the implementation of smart irrigation, water harvesting, composting plant residue and addition to soil, the station is moving towards optimizing the WEFE Nexus in practice.

Table G6.1. Solar installation techno-economic parameters

Item	**Description**
Project	Solar System Information – Phase II (EcoFuture Project)
Solar system capacity	29.7 kWp
Number of solar panels	90 panels, 330 Wp each
Inverter capacity	30 kW
Mounting structure	Galvanized steel
Solar system type	Grid-connected (Net Metering system)
Installation location	Deir Alla Agricultural Research Station / Agricultural land
Purpose of installation	Covering the additional electricity consumption for the EcoFuture project
Annual energy generation	46,800kWh
Annual savings	11640 Jordanian Dinars (JOD)

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Project Coordinator

Project Partners

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