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Perceived Economic Viability of Resilient Nature-Based Water Solutions in the Middle East and North Africa Region

Elizabeth Stifel, Wasudha Prabodhani Abeyrathna and Stephen Russell Fragaszy

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Front cover: Nile river in downtown Cairo, Egypt (*photo*: Momen Nabil/IWMI)

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Project

Al Murunah: Building Climate Resilience through Enhanced Water Security in MENA project (2022–2026) supported financially and technically by UK International Development and implemented by the International Water Management Institute (IWMI) in partnership with the International Union for Conservation of Nature (IUCN). The aim of Al Murunah is to enhance water security in Egypt, Jordan, Lebanon and Palestine by integrating nature-based solutions for water and agricultural water management.

Collaborators

International Water Management Institute (IWMI)

International Union for Conservation of Nature (IUCN)

Donor

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Abbreviations and Acronyms

AWM	Agricultural Water Management
CEDARE	Center for Environment and Development for the Arab Region and Europe
FCDO	Foreign, Commonwealth & Development Office
GEF	Global Environment Facility
GCF	Green Climate Fund
IWMI	International Water Management Institute
MENA	Middle East and North Africa
NbS	Nature-based Solutions
NbSI	Nature-based Solutions Initiative
RNBWS	Resilient Nature-Based Water Solutions
SLM	Sustainable Land Management
STEB	Short-Term Establishment Benefits
LTEB	Long-Term Establishment Benefits
USD	United States Dollar
WOCAT	World Overview of Conservation Approaches and Technologies

Summary

This report examines the economic viability of Resilient Nature-Based Water Solutions (RNBWS) in the Middle East and North Africa (MENA) region through monetary, quantitative, and perceptual data. Over 60% of the population in MENA faces high water stress compared to the global average of 35%. In this water-scarce region, agriculture consumes the largest share of water resources and is reliant on rapidly depleting groundwater reserves and surface water flows that are declining over time.

RNBWS combines nature-based approaches to increase water supply and improve quality with agricultural water management practices to reduce water demand and externalities on water quality. Using data from the World Overview of Conservation Approaches and Technologies (WOCAT), our study analyzed 24 projects we classified as RNBWS across the MENA region to evaluate their costs, benefits, and stakeholder perceptions of them.

While quantitative cost-benefit ratios could not be calculated due to data limitations, stakeholder perceptions provided valuable qualitative insights into a project's perceived economic viability and cost-effectiveness. Stakeholder perceptions followed a consistent pattern in which initial negative or neutral views during the short-term establishment phase (-0.41 on a -3 to +3 scale) transformed into strongly positive perceptions in the long term (+2.09). This transformation occurred across all project categories, regardless of whether they were classified by Sustainable Land Management measures (agronomic, vegetative, structural, or management) or Sustainable Land Management intervention types (management, restoration, or protection). Maintenance activities consistently received positive evaluations in both the short- and long-term (+1.43 and +2.41, respectively) across all project types, likely reflecting their relatively low costs and role to sustain rather than create new benefits.

The analysis revealed very low long-term maintenance costs for RNBWS, with an average of USD 72 per hectare per year. Up-front costs varied significantly by intervention, averaging USD 2,506 per hectare.

These findings indicate that while RNBWS projects ultimately provide favorable perceived cost-benefit outcomes in the MENA region (including a mix of public and private goods), financial support mechanisms are critical during the early implementation phase when perceived costs outweigh immediate benefits. This analysis addresses a critical knowledge gap regarding the economic viability of nature-based solutions for water scarcity in the region and offers evidence-based insights for policymakers, communities and donors. By demonstrating the long-term value of these interventions, this study supports informed decision-making for scaling up RNBWS as part of a comprehensive strategy to address the region's interconnected water, climate, agriculture and rural livelihoods challenges. Finally, the findings highlight the cost-effectiveness of maintaining water conservation systems as a sustainable approach to water management in resource-constrained environments.

1. Introduction

The Middle East and North Africa (MENA) region is the world's most water-scarce region, with over 60% of its population living under high water stress, compared to 35% globally (Al-Taani et al. 2021). Both surface and groundwater resources are under significant pressure due to rapid population growth and the rising demand for food and water. Across the MENA region, climate projections and socioeconomic trends call for immediate investments in water security and climate adaptation to prevent severe environmental impacts on both ecosystems and societies (World Bank, 2022). Significant efforts have been made to expand and improve the availability of and access to water sources, especially for irrigation purposes.

The agricultural sector in the MENA region is the largest consumer of water resources. Surface water is limited by the region's semi-arid and arid climate, and 70% of river basins cross national borders, complicating water access. As a result, groundwater has become the primary irrigation source. Unsustainable groundwater abstraction has led to widespread depletion (Dawoud, 2025). Groundwater depletion, alongside other interconnected challenges, such as soil salinization, high irrigation energy costs, and recurring droughts, is further compounded by climate change, which disrupts rainfall patterns and increases evapotranspiration rates. The health of the agriculture sector is at risk. Agriculture, both rain-fed and irrigated, plays a vital role in MENA economies and is the backbone of rural labor markets (Woertz, 2017).

Implementing comprehensive interventions to effectively address these issues is challenging. In areas with limited institutional capacity and fragmented governance structures, such efforts become increasingly unfeasible.

Conventional approaches and gray infrastructure solutions have traditionally been used in response to these complex socio-environmental challenges but have proven to be inadequate or even counterproductive. Levees, for example, can increase flood levels downstream and create a false sense of security that encourages human encroachment into flood-prone areas, ultimately resulting in greater flood damage (White, 1945). Nature-based Solutions (NbS), on the other hand, are defined as actions that "involve working with nature, as part of nature, to address societal challenges, supporting human well-being and biodiversity locally" (Nature-based Solutions Initiative (NbSI). The socio-ecological integration that gives NbS its strength also presents implementation challenges, including delayed recognition of benefits, requirements for ongoing community-driven maintenance and management, and potential conflicts between conservation and commercial activities. Despite these inherent tensions, NbS offer a promising alternative framework that works within ecological systems to provide multiple co-benefits, such as biodiversity conservation, carbon sequestration, and enhanced community resilience, while addressing the mounting pressures of climate change.

This paper reports on a subset of NbS referred to as Resilient Nature-Based Water Solutions (RNBWS), which combine a) nature-based water solutions (NBWS), which work with nature, as a part of nature, to increase water supply, and b) agricultural water management (AWM) practices, which reduce agricultural water demand.

At present, information on RNBWS in the MENA region is fragmented and generally limited. When RNBWS are studied, most evaluations only use a few case studies or focus on small areas. Evaluations tend to emphasize the qualitative social effects of RNBWS or focus only on the short- to medium-term biophysical effects of the interventions. Economic parameters of RNBWS technologies and perceived benefits of their implementation over time are particularly lacking. This economic gap hinders our understanding of RNBWS viability and impedes not only communities from making informed choices, but also governments from promoting their use and donors from supporting their adoption. These three groups working in tandem ultimately drive greater uptake and scalability.

While economic assessments are key for expansion in the region, assessing such dimensions for RNBWS remains difficult due to persistent methodological challenges. In terms of measuring costs, farm records are often incomplete or missing, and inputs like family labor and in-kind contributions are challenging to assign monetary value. The precise area where an intervention is applied is not always well-defined, further complicating cost estimates. Measuring benefits is even more complex, requiring accurate data on biophysical outcomes, as well as information on productivity gains and socio-economic impacts, all of which are frequently limited or unavailable. Valuing increased subsistence production is particularly difficult as these benefits often remain outside formal market systems.

Despite these hurdles, this analysis leverages the WOCAT database to examine the economic aspects of RNBWS in the MENA region. WOCAT provides valuable empirical data on establishment and maintenance costs, along with stakeholder perceptions of cost-benefit ratios of RNBWS for 24 projects across the MENA region. Projects in the database use robust methods to capture indirect and non-monetary benefits, offering a more comprehensive assessment of RNBWS effectiveness than is possible with other datasets.

By drawing on this data, we aim to deepen an understanding of how RNBWS interventions can simultaneously address the region’s interconnected environmental, social, and economic challenges in an integrated and sustainable way. As the first study to extract and synthesize MENA-specific RNBWS data from WOCAT (and later align it with complementary datasets, such as GCF and GEF project analyses), this work contributes to a more unified and holistic perspective on RNBWS efforts in the region.

2. Data and Methods

The WOCAT dataset includes 508 Sustainable Land Management (SLM) projects from across Asia, Europe, the Americas, Oceania, and Africa. SLM projects focus on using land resources sustainably for production while maintaining their long-term productivity and maintenance of their environmental functions. NbS is a more specific subset of SLM that emphasizes the role of nature in providing solutions.

For this analysis, projects were filtered in three main stages. First, only projects implemented in the MENA region were selected (country list found in Annex A). Second, MENA projects were evaluated against this Oxford definition of a NbS:

“Nature-based Solutions involve working with nature, as part of nature, to address societal challenges, supporting human well-being and biodiversity locally... . They are actions that are underpinned by biodiversity and designed and implemented in a way that respects the rights, values and knowledges of local communities and Indigenous Peoples (Nature Based Solutions Initiative, 2025).”

Third, to target RNBWS, we chose only those NbS pertaining to water. Because RNBWS also includes an element of AWM, projects that had elements that "[manage] water used in crop production (both rainfed and irrigated), livestock production and inland fisheries” (Chitima and Rutten 2015), were included.

For example, a Moroccan project that planted olive trees is considered an RNBWS because the project technologies worked with the natural ecosystem to increase soil moisture retention by stabilizing soil and reducing erosion. The initiative promoted sustainable water harvesting techniques, such as building terraces and swales, to capture and store rainwater. Additionally, the project used olive trees to improve groundwater recharge through increased infiltration and reduced runoff. In contrast, a grazeland project in Uzbekistan that divided up land into strips for better crop production was not included in this analysis because it did not incorporate agricultural water management techniques, nor did it emphasize working with nature.

There were 24 projects in total that matched our criteria. This paper reports on these projects in three configurations: 1) all RNBWS together, 2) RNBWS divided by Sustainable Land Management (SLM) measure, and 3) RNBWS divided by SLM intervention type. The WOCAT database assigned each project a SLM measure category, which corresponded to either structural, agronomic, vegetative, or management measure types. We manually assigned three SLM intervention types, which include restoration, protection, and management, according to Oxford’s NBS initiative taxonomy of intervention types. A summary of all included projects is available in Annex B. Definitions for SLM measures and interventions are given in Tables 1 and 2.

Table 1. Definitions of Sustainable Land Management measures.

SLM Measure	Definition	Examples
Agronomic	Practices applied to soil or crops to retain water and reduce water demand (co-benefits: improved fertility, reduced erosion)	Crop rotation, mulching, irrigation scheduling, composting
Vegetative	Use of plant cover to reduce runoff (co-benefits: stabilized soil, enhanced biodiversity)	Grass strips, tree planting, windbreaks
Structural	Physical constructions to manage water flow (co-benefits: reduced erosion, soil retention)	Terraces, bunds, check dams, retention basins
Management	Strategic or organizational approaches that guide water resources use and land use to improve water access and use (co-benefits: biodiversity protection, social equity)	Grazing control, land-use planning, community rules

Source: Elizabeth Stifel, author.

Table 2. Definitions of Sustainable Land Management interventions.

SLM Intervention	Definition	Examples
Restoration	Active (direct human involvement) or passive (natural recovery) restoration of natural or semi-natural ecosystems to rebuild natural features back to their original condition to produce long-term ecological protection.	Ecological restoration, functional restoration, habitat restoration, structural restoration, intervention ecology, reforestation, rehabilitation, reconstruction, revegetation
Protection	Marine, freshwater, and land site-specific protection of natural or semi-natural ecosystems by restricting access or setting it aside for preservation.	Protected areas, land enclosures, private land conservation measures, reserves, conservancies, locally managed marine areas with specific set aside "conservation zones."
Management	Natural or semi-natural ecosystem management interventions other than restoration or protection. Improving the land for useful ecosystem services and/or preventing further degradation by modifying ecosystems or using natural processes, without formally protecting the land.	Forest management (close-to-nature approaches)

Source: Elizabeth Stifel, author.

Cost variables were indexed to the US Dollar in 2020 to ensure comparability across years and countries. There were two main quantitative variables used to analyze the cost associated with RNBWS practices: establishment costs and maintenance costs. Establishment costs are specific one-off initial costs, expressed in US dollars per hectare, incurred to implement the RNBWS. These upfront costs can span over a period of a few weeks to one year. These costs typically include labor, purchase or rent of machinery and equipment, and purchase of seedlings. Maintenance costs refer to costs, expressed in US dollars per hectare per year, incurred on a regular basis to keep the system functioning. This generally consists of payments towards labor, equipment upkeep, and agricultural inputs. Landowners typically bore 100% of the costs of these interventions.

The dataset provides four qualitative proxy variables to assess benefits using the perspectives of the land users on how they perceive the benefits of a technology. These variables include perceived short term benefits relative to establishment costs (STEB), perceived long term benefits relative to establishment costs (LTEB), perceived short term benefits relative to maintenance costs (STMC), and perceived long term benefits relative to maintenance costs (LTMC). The short term refers to a period of up to three years from investment, whereas the long term is a period of 10 years after investment. Land users evaluated the benefits of a project on a scale indexed between −3, which represents a very negative perception of the project's benefits compared to its costs, up to +3, which represents a very positive perception of the project's benefits to its costs.

When we broke down the analysis by SLM measure and SLM intervention, we found that the number of projects within each category could vary significantly. To account for this uneven distribution, we use proportions rather than raw counts when applicable. This allows for a more accurate comparison of response patterns across categories. For instance, if three agronomic projects received a −2 score, this might only constitute 40% of that category's total projects. In contrast, two projects in another category might represent 50% of that category's total. By using proportions, we give more weight to the two projects representing 50% of their category than to the three projects representing only 40% of theirs, ensuring our analysis properly accounts for the relative significance within each category.

Cost-benefit measurements that accrue in the future should, according to investment theory, be discounted and therefore would need to be given less weight in the calculations than short-term benefits and costs. We do not apply a discount rate because the cost-benefit ratio variable relies on perception, which nonetheless takes the uncertainty and less usefulness of future benefits into account (Giger, 2015).

3. Analysis

Our study analyzed 24 RNBWS across the MENA region (Annex B). These projects span a variety of ecosystems and management approaches, with cropland being the dominant land use type, appearing in 75% of all projects. These plots supported a range of crops within legume, cereal, and fruit food groups; multiple projects specifically focused on olive trees. Most landowners combine subsistence and commercial production. Measured by household income, their economic status ranges from below the national poverty line to around the national average. 18 projects (75%) included cropland, 12 (50%) involved grazing land, and 7 (29%) incorporated forest areas, with several projects spanning more than one land type. The projects cover a moderate spatial scale, with an average area of 36.5 hectares per project.

The map in Figure 1 shows the geographic distribution of the RNBWS projects analyzed in our study. Each pin represents a unique project location, with some regions containing multiple projects shown as a single pin. One multi-site project is represented by several pins across its implementation areas.

Figure 1. Spatial distribution of Resilient Nature-Based Water Solution projects across the MENA region.
Source: Google Maps
Note: Several projects were implemented in the same city and are therefore only represented by one pin on the map.

Financial investment across project phases demonstrates a pattern of front-loaded expenditure, with establishment phases requiring substantially higher investments than maintenance phases. There was also major variability depending intervention types: the most expensive establishment cost recorded was USD 20,000 per hectare for a management intervention in Tunisia that included the purchase of a zero-tillage seeder, whereas the highest reported maintenance cost of USD 700 per hectare per year (from the same project) also included operational costs associated with hiring labor to run the equipment, plant material, and fertilizers (Table 3).

Average per-hectare establishment costs vary substantially across SLM categories (Table 3). Among SLM measures, vegetative (USD 4,700/ha), agronomic (USD 4,400/ha), and structural (USD 3,870/ha) approaches are considerably more expensive than management measures (USD 130/ha). Similarly, within SLM interventions, the average costs of management and restoration are approximately USD 3,500/ha and USD 2,000/ha higher, respectively, than those of protection measures (Table 3).

Table 3. Summary statistics of cost profiles across intervention and management categories.

	Obs	Mean	Std.	Min	Max
Intervention type					
Agronomic	9	4401	8404	69	26242
Management	1	139	.	139	139
Structural	8	3875	4095	19	11115
Vegetative	4	4701	8555	224	17529
other	2	184	227	24	345
Sustainable Land Management type					
Management	15	4394	6934	19	26242
Protection	2	838	989	139	1538
Restoration	7	3191	6436	24	17529
Establishment Cost per Ha (USD)	24	2507	5175	0	20000
Maintenance Cost per Ha (USD)	24	138	194	0	694

Source: Elizabeth Stifel, author.
Note: This table presents descriptive statistics for project costs disaggregated by intervention type, sustainable land management category, and total establishment and maintenance categories. Costs are expressed in US dollars per hectare.

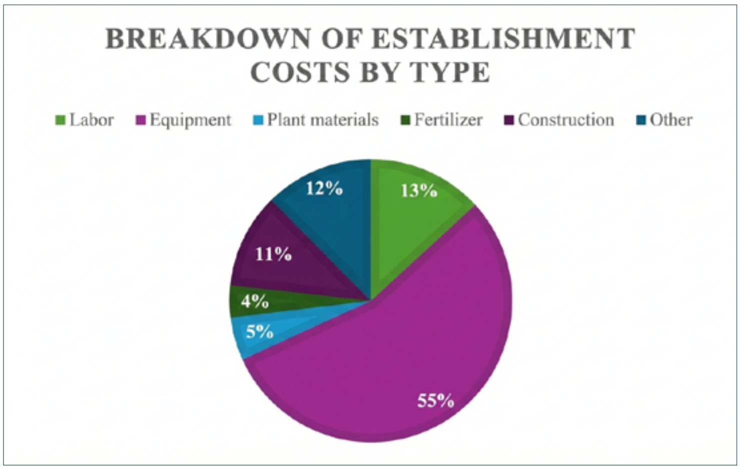

Figure 2. Breakdown of establishment costs by type.
Source: Elizabeth Stifel, author.
Note: This figure reports the breakdown of establishment costs across all 24 cases in our study.

The breakdown of maintenance costs into five main categories: equipment, labor, construction, fertilizer and plant material is given in Figure 3. Labor costs represent the majority of maintenance costs.

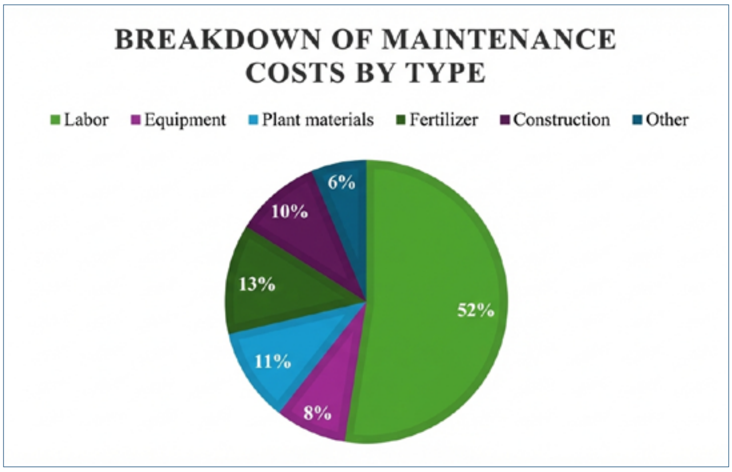

Figure 3. Breakdown of maintenance costs by type.
Source: Elizabeth Stifel, author.
Note: This figure reports the breakdown of establishment costs across all 24 cases in our study.

As indicated in Figure 2, establishment costs are broken into five main categories: equipment, labor, construction, fertilizer, and plant materials. Equipment costs represent the majority of establishment costs and can include examples such as tractors, seeders, rakes, farmers' knives, machetes, leather gloves, axes, etc. Figure 3 shows the breakdown of maintenance costs into five main categories: equipment, labor, construction, fertilizer, and plant materials. Labor costs represent the majority of maintenance costs.

Within establishment costs, equipment represents the largest expense, averaging approximately USD 1,400 per hectare per project. Other establishment expenses include construction, labor, and plant materials, each requiring between USD 200 and 400 per hectare of investment. These establishment costs differ from maintenance expenses, where even the highest cost category of labor required only USD 72 per hectare per year (Table 4).

Table 4. Cost composition of establishment and maintenance per hectare by input category.

Cost category	Establishment Costs (USD/ha)	Maintenance Costs (USD/ha)
Labor	330	72
Equipment	1379	11
Plant materials	121	15
Fertilizer	94	17
Construction	271	14
Other	311	9

Source: Elizabeth Stifel, author.
Note: This table presents the average per hectare costs of establishment and maintenance disaggregated by input category. All values are expressed in US dollars per hectare.

4. Overall Land User Benefit-Cost Perceptions

The mean value of the STEB for all projects is *slightly negative* (-0.41 on a -3 to +3 scale), indicating that, on average, stakeholders perceive initial establishment costs to slightly outweigh benefits. This perception aligns with the initial upfront investments of time, labor, or financial resources required to implement RNBWS measures, while benefits often take time to materialize. Higher establishment costs are associated with lower short-term perception scores, where land users gave lower-establishment-cost projects a neutral rating (0) versus higher-establishment-cost projects (those in the top 50th percentile) a poorer rating (-0.67).

Table 5. Landowner perceptions of Resilient Nature-Based Water Solutions across phases and time frames.

Variable	Observed	Mean	Std.	Min	Max
Short Term Establishment Benefits	22	-0.4090909	1.967815	-3 [-3]	3
Long Term Establishment Benefits	22	2.090909	0.8111773	-3 [0]	3
Short Term Maintenance Benefits	23	1.434783	1.590486	-3 [-2]	3
Long Term Maintenance Benefits	22	2.409091	0.7341397	-3 [0]	3

Source: Elizabeth Stifel, author.
Note: Table 5 gives summary statistics for landowner perceptions of resilient nature-based water solutions in the establishment phase and maintenance phase, in both the short and long terms. The numbers within brackets under the “Min” column represent the lowest responses recorded.

This pattern can be seen in a Morocco project involving fruit and forest plantations with terrace construction and small agricultural equipment. This project had an establishment cost of USD 16,204 per hectare, significantly exceeding the establishment average of USD 2,506 per hectare across projects, and it received a low short-term benefit rating (-2 on the -3 to +3 scale).

In the long term, however, the Long-Term Establishment Benefits LTEB mean across projects rises significantly to 2.09 (on the same -3 to +3 scale), indicating land users, who bear the majority of the intervention costs, ultimately view establishment investments in RNBWS as highly worthwhile. The same Morocco project that was initially rated *negative* (-2) received the highest possible, *very positive* rating (3) in the long run, which is consistent with the hypothesis that perceptions improved as benefits materialized.

The Short-Term Maintenance Benefits (STMB) average for all projects is *positive* (1.43 on the -3 to +3 scale), suggesting that maintaining existing interventions is viewed favorably even in the short term. This perception reflects the comparatively lower costs of maintenance versus establishment, as well as the fact that maintenance preserves already-visible benefits rather than creating new ones. In the Morocco project, the annual maintenance cost was only USD 147 per hectare per year, and it received a *positive* short-term maintenance rating (2) and a *very positive* (3) perception rating in the long term. This example demonstrates that once benefits become apparent, the relatively small cost to maintain the benefits is considered worthwhile.

The Long-Term Maintenance Benefits (LTMB) have the highest average score (2.41 on the -3 to +3 scale), with a relatively low standard deviation indicating broad consensus about these benefits. This *very positive* rating reflects landowners' confidence in the ongoing economic and environmental value of maintaining established interventions, reinforcing the appeal of maintenance as a sustainable and cost-effective investment compared to new establishment efforts.

5. Land User Benefit-Cost Perceptions by SLM Measure

Tables 6–7 present landowners' perceptions of short-term and long-term *establishment* benefits of sustainable land management measures, while Tables 8–9 present their perceptions of short-term and long-term *maintenance* benefits. Proportions presented in Tables 6–9 range from 0–1 are based on responses from the full sample of 24 projects. The distribution of observations by intervention type is as follows: agronomic 9 projects, structural 8, vegetative 4, management 1, and other 2.

Table 6. Landowner perceptions of Short-Term Establishment Benefits by Sustainable Land Management Measures.

Short Term Establishment Benefits	Very Negative	Negative	Slightly Negative	Neutral	Slightly positive	Positive	Very positive
Agronomic	0.00	0.43	0.00	0.14	0.14	0.14	0.14
Structural	0.13	0.13	0.13	0.13	0.13	0.25	0.13
Vegetative	0.25	0.50	0.00	0.25	0.00	0.00	0.00
Management	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.50	0.50	0.00	0.00	0.00

Source: Elizabeth Stifel, author.

Table 7. Landowner perceptions of Long-Term Establishment Benefits by Sustainable Land Management Measures.

Long Term Establishment Benefits	Very Negative	Negative	Slightly Negative	Neutral	Slightly positive	Positive	Very positive
Agronomic	0.00	0.00	0.00	0.00	0.29	0.29	0.43
Structural	0.00	0.00	0.00	0.00	0.13	0.50	0.38
Vegetative	0.00	0.00	0.00	0.00	0.00	0.75	0.25
Management	0.00	0.00	0.00	1.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	1.00	0.00

Source: Elizabeth Stifel, author.

Table 8. Landowner Perceptions of Short-Term Maintenance Benefits by Sustainable Land Management Measures.

Long Term Establishment Benefits	Very Negative	Negative	Slightly Negative	Neutral	Slightly positive	Positive	Very positive
Agronomic	0.00	0.00	0.11	0.11	0.11	0.22	0.44
Structural	0.00	0.00	0.14	0.14	0.00	0.43	0.29
Vegetative	0.00	0.25	0.00	0.25	0.00	0.25	0.25
Management	0.00	0.00	0.00	1.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.50	0.00	0.00	0.50

Source: Elizabeth Stifel, author.

Table 9. Landowner perceptions of Long-Term Maintenance Benefits by Sustainable Land Management Measures.

Long Term Maintenance Benefits	Very Negative	Negative	Slightly Negative	Neutral	Slightly positive	Positive	Very positive
Agronomic	0.00	0.00	0.00	0.11	0.00	0.22	0.56
Structural	0.00	0.00	0.00	0.00	0.00	0.71	0.29
Vegetative	0.00	0.00	0.00	0.00	0.00	0.50	0.50
Management	0.00	0.00	0.00	0.00	0.00	1.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	1.00

Source: Elizabeth Stifel, author.

Similarly, Figures 4–5 present landowners' perceptions of short- and long-term *establishment* benefits of sustainable land management measures, while Figures 6–7 present their perceptions of short- and long-term *maintenance* benefits as percentages. Proportions presented in Figures 4–7 range from 0–1 are based on responses from the full sample of 24 projects. The distribution of observations by intervention type is as follows: agronomic 9 projects, structural 8, vegetative 4, management 1, and other 2.

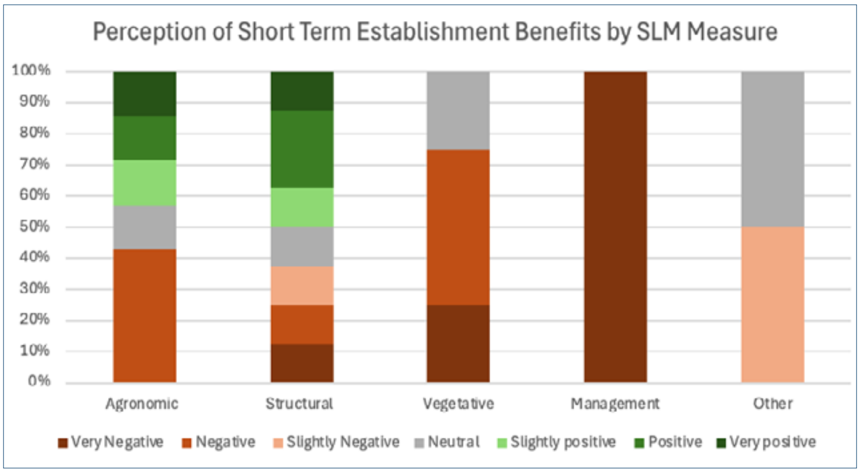

Figure 4. Landowner perceptions of Short-Term Establishment Benefits by Sustainable Land Management Measure.
Source: Elizabeth Stifel, author.

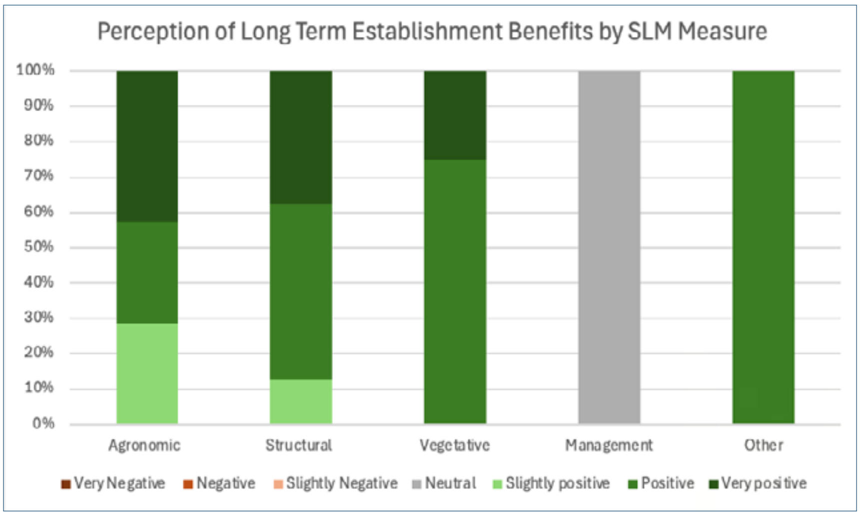

Figure 5. Landowner perceptions of Long-Term Establishment Benefits by Sustainable Land Management Measure.
Source: Elizabeth Stifel, author.

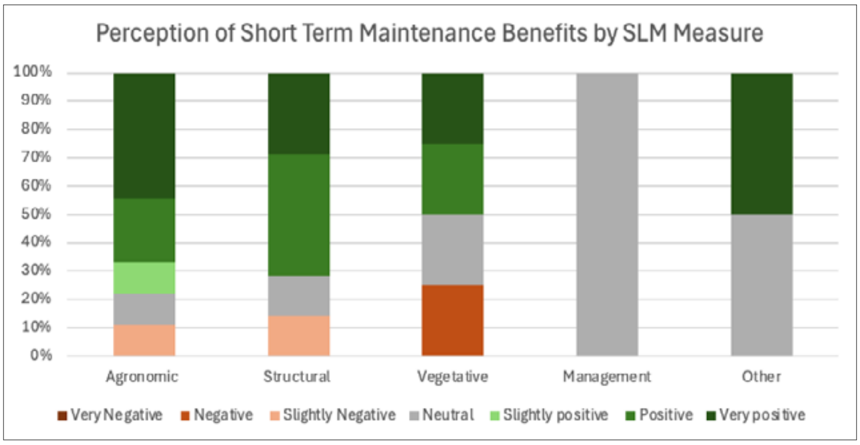

Figure 6. Landowner Perceptions of Short-Term Maintenance Benefits by Sustainable Land Management Measure. *Source*: Authors.
Source: Elizabeth Stifel, author.

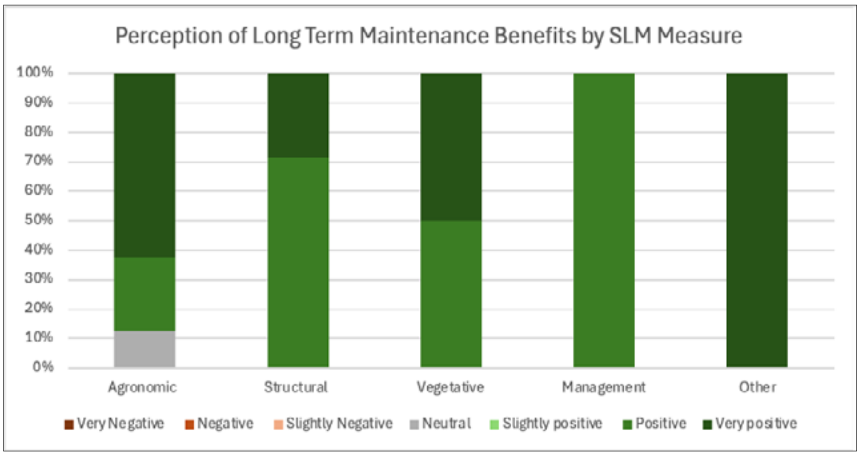

Figure 7. Landowner Perceptions of Long-Term Maintenance Benefits by Sustainable Land Management Measure. *Source*: Authors.
Source: Elizabeth Stifel, author.

Agronomic and structural measures accounted for most projects, respectively representing 38% and 33% of the projects. Vegetative measures made up a smaller portion at 17%, while management measures (8%) and other measures (4%) comprised the smallest categories. Due to the limited number of observations (only 3 total) for management and other measures, we do not discuss these categories in depth as there are insufficient data points to make meaningful generalizations.

Our analysis shows that while landowners initially perceived negative benefits across all measures in the short term, their perceptions became increasingly positive over the long term. While the general trend is similar across measures, there was a higher variance for agronomic and structural measures, likely due to differences in how quickly these projects show results. Take, for instance, two different agronomic projects: a drip irrigation project in Turkey where rollout of irrigation equipment and technical know-how requires significant time to fulfill, versus a pasture restoration project in Tunisia using drought-tolerant legumes, which can grow quickly and provide benefits within a single harvest cycle. Landowners perceived the drip irrigation project with a long-term horizon *very negatively* (-2), whereas landowners marked the pasture restoration project with *very positive* short-term ratings, thereby creating this variance.

In contrast, for vegetative measures, landowners reported negative perceptions in the short term for establishment benefits with little variation. These measures had little opportunity for fast-acting benefits because they primarily involved planting trees, which typically require years to grow and offer substantive returns.

Overall, landowners positively perceived maintenance costs across all categories and in both the short and long terms.

6. Land User Benefit-Cost Perceptions by SLM Intervention

Tables 10–11 present small and medium-scale landowners' perceptions of short-term (0–3 years) and long-term (between 3–10 years) *establishment* benefits of sustainable land management interventions, while Tables 12–13 present their perceptions of short-term and long-term *maintenance* benefits. Proportions presented in Tables 10–13 range from 0–1 and are based on responses from the full sample of 24 projects. The distribution of observations by intervention type is as follows: management 15, restoration 7, protection 2. Individual projects classified the scale their landowners worked, but generally small landowners held <0.5 to 5 ha, medium-scale landowners owned 5–50 ha, and large-scale landowners owned >50 ha.

Table 10. Landowner perceptions of Short-Term Establishment Benefits by Sustainable Land Management Intervention.

Short Term Establishment Benefits	Very Negative	Negative	Slightly Negative	Neutral	Slightly Positive	Positive	Very Positive
Management	0.07	0.29	0.14	0.07	0.14	0.21	0.07
Restoration	0.33	0.00	0.00	0.33	0.00	0.00	0.33
Protection	0.20	0.40	0.00	0.40	0.00	0.00	0.00

Source: Elizabeth Stifel, author.

Table 11. Landowner Perceptions of Long-Term Establishment Benefits by Sustainable Land Management Intervention.

Long Term Establishment Benefits	Very Negative	Negative	Slightly Negative	Neutral	Slightly Positive	Positive	Very Positive
Management	0.00	0.00	0.00	0.00	0.14	0.50	0.36
Restoration	0.00	0.00	0.00	0.00	0.00	0.67	0.33
Protection	0.00	0.00	0.00	0.20	0.20	0.40	0.20

Source: Elizabeth Stifel, author.

Table 12. Landowner Perceptions of Short-Term Maintenance Benefits by Sustainable Land Management Intervention.

Short Term Maintenance Benefits	Very Negative	Negative	Slightly Negative	Neutral	Slightly Positive	Positive	Very Positive
Management	0.00	0.00	0.07	0.13	0.07	0.40	0.33
Restoration	0.00	0.00	0.00	0.33	0.00	0.00	0.67
Protection	0.00	0.20	0.20	0.40	0.00	0.00	0.20

Source: Elizabeth Stifel, author.

Table 13. Landowner Perceptions of Long-Term Maintenance Benefits by Sustainable Land Management Intervention.

Long Term Maintenance Benefits	Very Negative	Negative	Slightly Negative	Neutral	Slightly Positive	Positive	Very Positive
Management	0.00	0.00	0.00	0.07	0.00	0.21	0.50
Restoration	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Protection	0.00	0.00	0.00	0.20	0.00	0.60	0.20

Source: Elizabeth Stifel, author.

Similarly, Figures 8–9 present landowners' perceptions of short- to long-term *establishment* benefits of sustainable land management interventions, while Figures 10–11 present their perceptions of short- and long-term *maintenance* benefits. Proportions presented in Figures 8–11 range from 0–1 and are based on responses from the full sample of 24 projects. The distribution of observations by intervention type is as follows: management 15, restoration 7, protection 2.

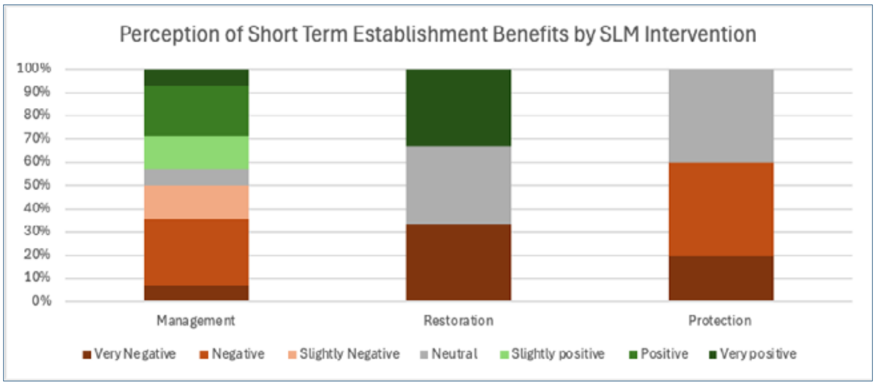

Figure 8. Landowner Perceptions of Short-Term Establishment Benefits by Sustainable Land Management Intervention.
Source: Elizabeth Stifel, author.

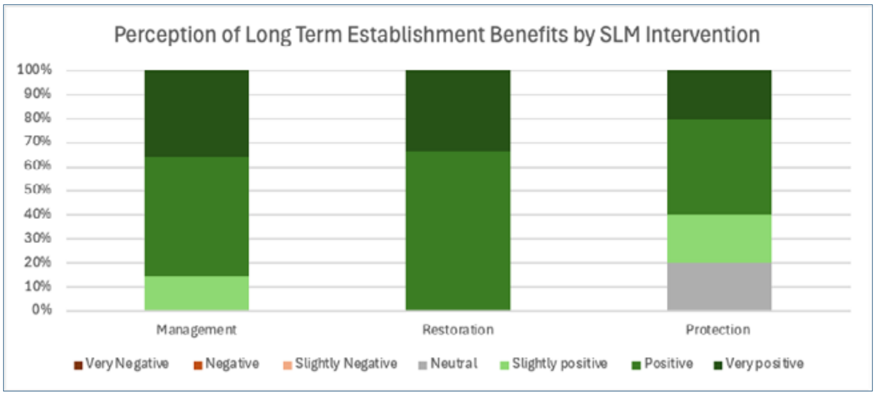

Figure 9. Landowner Perceptions of Long-Term Establishment Benefits by Sustainable Land Management Intervention.
Source: Elizabeth Stifel, author.

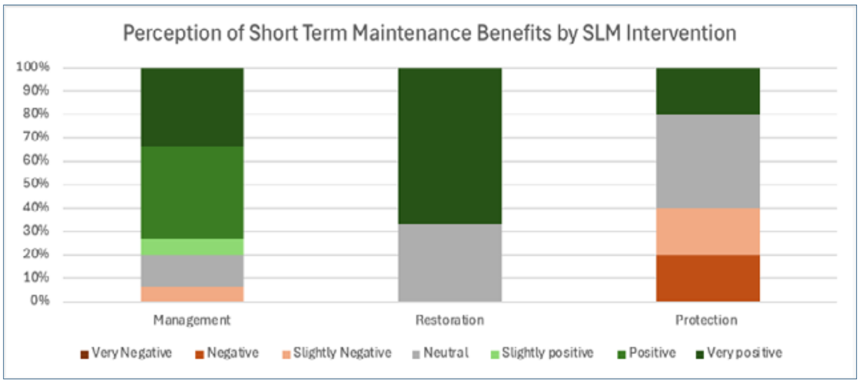

Figure 10. Landowner Perceptions of Short-Term Maintenance Benefits by Sustainable Land Management Intervention.
Source: Authors.
Source: Elizabeth Stifel, author.

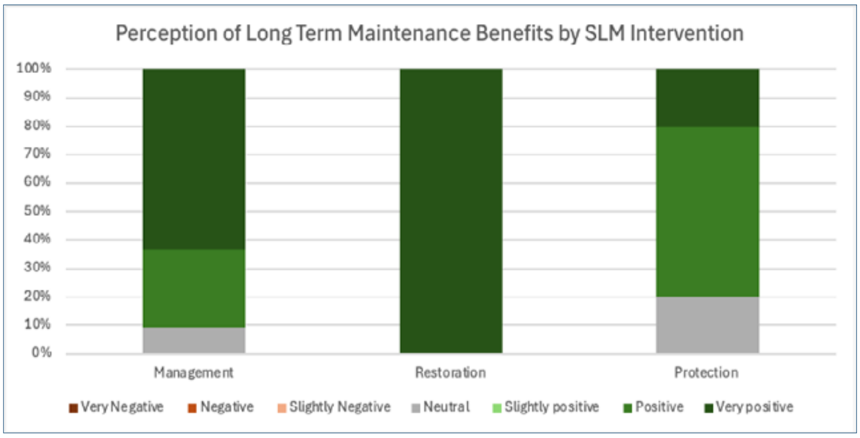

Figure 11. Landowner Perceptions of Long-Term Maintenance Benefits by Sustainable Land Management Intervention. *Source*: Elizabeth Stifel, author.

Management interventions dominated the project pool, accounting for 66% of all projects. Protection interventions followed at approximately 21%, with restoration interventions representing the fewest projects at just 13%.

While SLM interventions followed the general trend of poor perception of short-term establishment benefits to positive perceptions of long-term establishment benefits, each intervention type showed slightly different patterns of landowner satisfaction.

Management projects initially received mixed reviews. Some landowners experienced disruption, while others saw immediate livelihood value. For example, in Jordan, tractor ploughs for micro water harvesting were initially viewed negatively because they disturbed the land before their water collection benefits became apparent. However, in Jordan, cistern reservoirs were immediately appreciated because they provided useful water storage early on. Over time, landowners eventually viewed most management projects as worthwhile investments.

Restoration projects initially faced skepticism but showed the largest average increase in long-term perception scores in our sample. Landowners reported that these projects substantially improved their land productivity and sustainability. For example, a project in Morocco planted local species adapted to the conditions of the environment. Their benefits would have been low in the short term as the native species took time to reduce land degradation, but since these plants were well-adapted to the environment, over time, they likely flourished.

Protection projects, which restrict land use to allow natural recovery, faced the most initial resistance, likely because they limited productive activities while waiting for environmental benefits. After a fire devastated the land, a rehabilitation project in Morocco planted natural vegetation, but restricted animals from grazing and people from collecting wood. Landowners eventually recognized positive benefits of these projects in recovering the land, though their enthusiasm remained more moderate than other intervention types, as the lost opportunity cost of benefits also likely played a role.

During the maintenance phase, management projects continued to be well-received throughout both the short and long terms, as landowners consistently found them beneficial to their operations. Restoration projects showed the most dramatic improvement in landowner perception, starting with moderate satisfaction but achieving unanimous strong approval in the long term as ecological improvements translated to tangible benefits like improved soil quality or increased vegetation. Protection projects remained the least popular, with moderate satisfaction levels even after long-term implementation, likely because restrictions on land use continued to limit some productive activities throughout the maintenance period.

7. Conclusion

Our study examined perception-based economic viability of RNBWS projects in the MENA region across project phases and time horizons. The temporal analysis demonstrates that while initial establishment can present barriers, all sustainable land management measures ultimately generate substantial (perceived) value for participating landowners in terms of providing environmental and economic benefits. It is important to note that these results are perception-based and describe associations; they do not by themselves establish realized economic returns or causal effects.

The establishment phase had a high average cost, with most of the resources directed towards equipment. This phase typically had negative perceptions of costs, likely due to high upfront investments with minimal immediate returns, especially for vegetative measures like tree planting, management interventions such as water harvesting using tractor plows, and protection interventions like restricted grazing areas. This cost-benefit imbalance may create adoption barriers, particularly for capital-intensive projects requiring significant initial expenditure. The timing of perception changes is consistent with the hypothesis that benefits became more apparent over time. However, testing this hypothesis requires longitudinal data, exogenous variation, or objective outcome measures (e.g., yields, water metrics).

Our analysis reveals that all SLM measures and intervention categories eventually yield benefits that landowners recognize as substantially valuable relative to their investments. Vegetative measures exhibit the most dramatic perceptual transformations, shifting from negative to strongly positive assessments. This is likely due to most projects planting trees, which mature and deliver their full suite of ecosystem services, including erosion control, enhanced soil moisture retention, and microclimate improvements over long-time horizons.

Protection interventions also encountered strong initial resistance from landowners who experienced immediate constraints on livelihood activities. In contrast, interventions that permit continued land use during improvement phases had significantly better initial acceptance rates. Thus, future implementation of RNBWS should strive for continued land use when possible or offer subsidized household or community benefits when this option is unavailable to make up for lost individual costs.

The maintenance phase exhibited a lower average cost than the establishment phase, with most resources diverted towards labor. This phase demonstrated more consistent positive landowner perceptions across all measures and intervention types. Sustaining existing water conservation infrastructure requires substantially lower investment than initial establishment while delivering continued or enhanced benefits.

Strong RNBWS projects will include implementation strategies that account for the temporal dynamics of cost-benefit perception. Support programs that bridge the initial implementation gap, such as through subsidies, technical assistance, or phased benefit delivery, could accelerate RNBWS adoption across the region's diverse agricultural and pastoral systems.

The maintenance phase findings are particularly significant for regional water security planning. Existing water conservation systems represent high-value investments that generate ongoing benefits at relatively low cost while maintaining strong landowner support. This suggests that preserving and enhancing current RNBWS infrastructure should be prioritized alongside new project development.

For the broader MENA context, where water scarcity is intensifying and climate variability is increasing, these findings suggest that RNBWS can achieve widespread landowner acceptance and long-term sustainability. However, increased data collection across projects will need to be conducted to produce more rigorous numerical economic analyses, based not on perceptions but on actual costs and benefits. For RNBWS, this means quantifying the impacts on water. This will give decision makers more concrete information about the economic impacts of RNWBS.

In conclusion, our evidence supports a dual strategy: expanding new RNBWS projects with robust early-phase support, combined with investment in maintaining and optimizing existing water conservation infrastructure. This approach maximizes both immediate water security benefits and long-term landowner engagement, positioning RNBWS as a cornerstone of regional climate adaptation and sustainable water management strategies.

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Annexes

Annex A. Country List

- Algeria
- Bahrain
- Egypt
- Iran
- Iraq
- Israel
- Jordan
- Kuwait
- Lebanon
- Libya
- Morocco
- Oman
- Qatar
- Saudi Arabia
- Occupied Palestinian Territories
- Syria
- Tunisia
- Turkey
- United Arab Emirates
- Yemen
- Sudan
- Mauritania
- Mali
- Chad

Annex B. Projects

5860 (Jordan): Tractor plough system breaks up compacted soil to create micro water harvesting pits that capture rainfall for rangeland rehabilitation.

3232 (Morocco): Project uses locally adapted plant species to reduce land degradation and restore severely degraded lands.

2842 (Morocco): Tree plantation combining rainwater harvesting tanks, earth mounds around trees, and drip irrigation for controlled water supply.

1428 (Morocco): Cork oak regeneration project using seedlings in protected test plots with soil and water conservation measures to fight desertification.

3210 (Morocco): Post-fire rehabilitation through area exclusion (preventing grazing and wood collection) to allow natural vegetation recovery.

2897 (Morocco): Fruit and forest tree plantations with terraced construction and fertilizers to prevent erosion and slow water runoff.

1112 (Morocco): Olive tree plantations with intercropping and drip irrigation, designed to prevent livestock intrusion.

1707 (Morocco): Agro-forestry system using traditional seguia irrigation channels to grow fruit and forest trees with crops while controlling erosion.

1195 (Morocco): Fruit tree plantation with terraced erosion control, intercropping forest and fruit trees, using sustainable fertilizers and pest control.

1292 (Sudan): Water spreading system using earth dam structures and channelized runoff for spate irrigation.

1549 (Syria): Semi-circle bunds on steep slopes for soil and water harvesting that reduce erosion and increase olive tree productivity.

1410 (Syria): Range restoration using pitting and reseeding techniques with shallow pits that collect rainwater and shelter young plants.

1005 (Syria): V-shaped micro catchments for olive trees that harvest runoff, save irrigation water, and capture eroded soil particles.

1568 (Tunisia): Area closure and reforestation with drought-resistant Acacia trees planted in rainwater-harvesting infiltration pits to restore forest steppe ecosystems.

5819 (Tunisia): Conservation agriculture using biennial legume-cereal rotation with integrated livestock management.

1412 (Tunisia): Recharge well system with drilled holes and filters that inject floodwater directly into aquifers for groundwater replenishment.

1013 (Tunisia): Ancient runoff water harvesting technique that collects and channels water for crop production, aquifer recharge, and erosion control.

1420 (Tunisia): Modern version of ancient water harvesting system for soil erosion control, groundwater management, and supporting tree and crop production.

3727 (Tunisia): Agricultural conservation approach using minimal soil disturbance, permanent cover, and crop diversification to reduce erosion and increase fertility.

4055 (Tunisia): Direct seeding conservation system with chemical weeding, permanent soil cover, and crop rotation.

5919 (Tunisia): Pasture restoration using drought-tolerant legumes to restore degraded soils, fix nitrogen, and improve biodiversity.

1413 (Tunisia): Cistern system for storing rainfall and runoff water for drinking, animal watering, and supplemental irrigation.

1014 (Turkey): Drip irrigation system for efficient water delivery.

1535 (Turkey): Woven wood fence system for area protection.

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