Farming systems enhancement in North-Eastern Badia Highlands, Jordan

INTERNATIONAL UNION FOR CONSERVATION OF NATURE - REGIONAL OFFICE FOR WEST ASIA

Subcontractor:

About IUCN

IUCN is a membership Union uniquely composed of both government and civil society organisations. It provides public, private and non-governmental organisations with the knowledge and tools that enable human progress, economic development and nature conservation to take place together.

Created in 1948, IUCN is now the world's largest and most diverse environmental network, harnessing the knowledge, resources and reach of more than 1,400 Member organisations and around 15,000 experts. It is a leading provider of conservation data, assessments and analysis. Its broad membership enables IUCN to fill the role of incubator and trusted repository of best practices, tools and international standards.

IUCN provides a neutral space in which diverse stakeholders including governments, NGOs, scientists, businesses, local communities, indigenous peoples organisations and others can work together to forge and implement solutions to environmental challenges and achieve sustainable development.

Working with many partners and supporters, IUCN implements a large and diverse portfolio of conservation projects worldwide. Combining the latest science with the traditional knowledge of local communities, these projects work to reverse habitat loss, restore ecosystems and improve people's well-being.

http://www.iucn.org

https://twitter.com/IUCN/

Farming systems enhancement in North-East Badia Highlands, Jordan

IUCN is pleased to acknowledge the support of its Framework Partners who provide core funding: Ministry of Foreign Affairs, Denmark; Ministry for Foreign Affairs, Finland; Government of France and the French Development Agency (AFD); Ministry of Environment, Republic of Korea; Ministry of the Environment, Climate and Sustainable Development, Grand Duchy of Luxembourg; the Norwegian Agency for Development Cooperation (Norad); the Swedish International Development Cooperation Agency (Sida); the Swiss Agency for Development and Cooperation (SDC) and the United States Department of State.

Published by: IUCN, Gland, Switzerland

Produced by: IUCN Regional Office for West Asia (ROWA)

Recommended citation: IUCN (2023). *Farming systems enhancement in North-East Badia Highlands, Jordan.* Gland, Switzerland: IUCN.

Cover photo: © Smart DESERT Team

Layout by: Mohammad Abu Tarboush

Contents


Photo credit: Smart DESERT project team

1. Smart DESERT project

1.1 An overview

As the world's second-largest refugee-hosting country, Jordan faces major strains on its economy and natural resources. Though the international community has stepped in to relieve the burdens of the Syrian refugees crisis , matching resources with growing needs have proven difficult, particularly with regard to workforce inclusion. Jordan suffers from a high rate of unemployment (19% nationally) and rising poverty, with nearly 16% of Jordanians and 78% of Syrian refugees are living below the poverty line – a trend likely to worsen as the impact of the COVID-19 pandemic continues to unfold.

Overall, working in the agricultural sector is characterized by low wages, long hours, poor working conditions, lack of occupational health and safety, and a high incidence of child labor. According to estimates conducted by the International Labour Organization (ILO), close to 70% of workers on farms are Syrian refugees. Syrian workers often bring their entire families to live at the farm, where employers do not always provide decent accommodations, especially for children or the elderly. The lack of suitable childcare arrangements and accessible schooling options often lead farm workers to bring their children to work, exposing them to health and safety hazards. Women and girls are especially vulnerable on farms, where they are at risk of exploitation and gender-based violence. The COVID-19 pandemic has exacerbated the vulnerabilities of Syrian and Jordanian agricultural workers, leading to increase poverty, deteriorating wages and work conditions, and higher risks to children, including school dropout, child labor, and child marriage.

In addition to competition over jobs and a large informal economy, Jordan faces severe water scarcity, with annual demand roughly double the available supply and weak water resource management exacerbating the problem. Since the outbreak of the Syrian conflict in 2011, the northern governorates; Mafraq, Amman, Irbid, and Zarqa – where 90% of Syrians living outside refugee camps are concentrated – have experienced the highest increase in unemployment, along with a 40% rise in water demand (compared to 21% nationally).

Climate change further threatens water supply and agricultural sector that is also constrained by limited arable land. Contributing 4% of GDP and 15% of employment, agriculture still accounts for up to 75% of Jordan's total water consumption. The scarcity of water and productive land prone a risk to food security, leading to low agricultural yields and overreliance on imports as the agricultural sector supplies less than 20% of the country's food. Furthermore, increased groundwater salinity in the past 30 years has had a negative impact on crop yield and farmer incomes. Due to lack of knowledge, farmers tend to over-irrigate to wash out salts accumulated around the root of different crops, increasing water and energy costs while threatening sustainability due to soil salinization. The lack of know-how on saline water irrigation is leading to poor crop quality and adding stresses on vulnerable farmers, with adverse effects on marketing potential.

Drawing on over 15 years of experience in Jordan, deep contextual knowledge, and vast networks with local stakeholders, the International Union for Conservation of Nature (IUCN) has formed a consortium of partners with complementary expertise to address the range of challenges and opportunities facing vulnerable populations in the agricultural sector. The IUCN team brings together proven leaders in agriculture, water, and livelihoods, it combines local innovations with international best practices to shape impactful initiatives that will boost and diversify incomes, improve work conditions, and address the complex vulnerabilities affecting Syrian refugees and the Jordanian host communities where they reside in.

Consortium partners are Inter-Islamic Network on Water Resources Development and Management (INWRDAM), Blumont International (Blumont), Horizons for Green Development (Horizons), and GreenTech, as well as the National Agricultural Research Center (NARC) as subcontractor.

With an overarching goal of economic empowerment of Syrian refugees and vulnerable Jordanians in the agricultural sector, Smart DESERT is established to achieve two key objectives: (1) increased year-round income and (2) improved work conditions. Given the complex issues at stake, the IUCN consortium will maintain a dual focus on “hard” and “soft” activities combining technical and business/socioeconomic aspects. Hard activities will focus on technical support to farms, agro-processing facilities, and Home-based Businesses (HBBs) through a holistic water-energy-food-health nexus approach that includes the usage of non-traditional water resources to reduce freshwater use, renewable energy to reduce operational costs, and smart crop selection and processing to improve agricultural productivity, economic output, and regularity of income. On the other hand,soft activities will entail training, advocacy, and business linkages to improve working conditions and link beneficiaries to the market, helping to create an enabling environment for economic growth.

1.2 The project area

In light of the above contextual realities highlight, innovative pathways are needed to improve the livelihoods of Syrian refugees and vulnerable Jordanians in the agricultural sector through holistic support related to technicalbusiness, and labor conditions at the level of farms (including livestock farms), agro-processing facilities, and HBBs. With this in mind, our intervention will focus on the northern highlands, specifically North-East Badiathat is inhabited by half-a-million Syrian refugees (including Zaa'tari Camp) and an equal number of Jordanians whose livelihoods depend on agriculture, primarily consisting of fruit and vegetable crops, North-East Badia provides strong potential for high-impact socioeconomic empowerment through improved on-farm practices, decent work conditions, and development of the HBB sector to increase year-round income.

Due to competition with large farms, small farmers primarily sell products to local markets at relatively low margins, as well as to small agro-processors. However, rising production costs threaten the viability of processing industries and have led to the closure of all tomato-processing plants. Rehabilitating and supporting such facilities would therefore yield substantial multiplier effects on the small farms supplying them. Furthermore, linkages to export markets would not only improve the economic outputs of small farmers, but also enhance quality and work conditions due to the strict standards required by these markets.

In addition to crops, North-East Badia is also home to over half of the country's livestock (1.2 million heads of livestock), including sheep, lambs, and some of the largest cow farms in the country. Each year, thousands of tons of cow waste are composted for fertilizers with almost zero energy recovery. In addition, the knowledge of livestock owners in veterinary care and animal nutrients is limited as they tend to follow age-old practices that yield low benefit.

While small ruminants are often the sole source of income for many rural households, particularly smallholder livestock farmers and Syrian refugees, few agencies are supporting those who depend on livestock for their livelihoods. Among them, the ILO has since 2016 recognized the potential of the livestock sector to increase jobs and incomes for Syrian refugees and vulnerable Jordanians at the micro or even home-based level.

The high cost of livestock feeding is a major barrier to growth in the dairy value chain in Mafraq. Animal feeding represents less than 5% of local production and only covers 30% of the region's needs due in large part to the current configuration of its water infrastructure. Though North-East Badia is the country's largest irrigated farmland area (1,400 km^2) and the second-largest in terms of food production, the level of local fodder production and import substitution can be increased using available brackish and saline water as new irrigation sources. In addition to two river basins, the area has five wastewater treatment plants and around 70 brackish and saline water wells with an annual capacity of 30 million m^3, providing a valuable resource for productive farming if properly used. The project area is generally characterized by arid and semi-arid conditions, and generally receives 50–300 mm/year of precipitation, which can be described as unreliable for agricultural production for a wide range of crops. Climate change projections suggest that precipitation would likely decrease in the future in this region. Furthermore, farmlands in this area experience mild to extreme levels of droughts, with irregular patterns, which are likely to increase in the future. This would likely have a devastating impact on crop production without suitable intervention.

Photo credit: Smart DESERT project team

Photo credit: Smart DESERT project team

2. Rehabilitation of low-output farmlands

2.1 Selection methodology

In a timeframe of one month, 1,550 applications were received through KoBo collect online tool. The application (Annex 1) comprised basically two sections; conditions and selection criteria. Generally, the first section (conditions) is an obligation of the applicant to hiring new labors, in case of selection of his/her farm. In addition, he/she obligates to provide the labors with decent working conditions as per the Jordanian labour law. On the other hand, the second section of the application form (selection criteria) comprised the aspects which the evaluation will be based on; these include but not limited to the following:

- Usage of non-conventional water resources (treated wastewater, saline water, and harvested rainwater).
- Membership in cooperatives.
- Willingness to cultivate new crops.
- Potential for public–private partnerships.
- Employment growth potential.

As a summery, the first section (conditions) is a pre-qualification step for the second section (selection criteria). Applications were screened through the first stage, thereafter, the qualified applications were filtered according to the geographical boundaries of the project. All of the qualified applicants were contacted through the phone in order to further assess the acceptability of the applicant to the project conditions and the availability of the major farm components since this intervention is allocated for existing farms. Field visits were conducted to the final candidate farms in order to verify the submitted information.

2.2. Locations of the selected farms

Twenty farms were selected according to the selection methodology mentioned in the previous section (2.1). These farms are distributed among the project areas which comprises around a set of municipalities in four governorates. However, no farms were located in a few municipalities, by chance. Therefore, these municipalities will be prioritized in the second round of rehabilitation (during 2022). The twenty selected farms and a demonstration site (Introduced in section 3) are exhibited in figure 1.

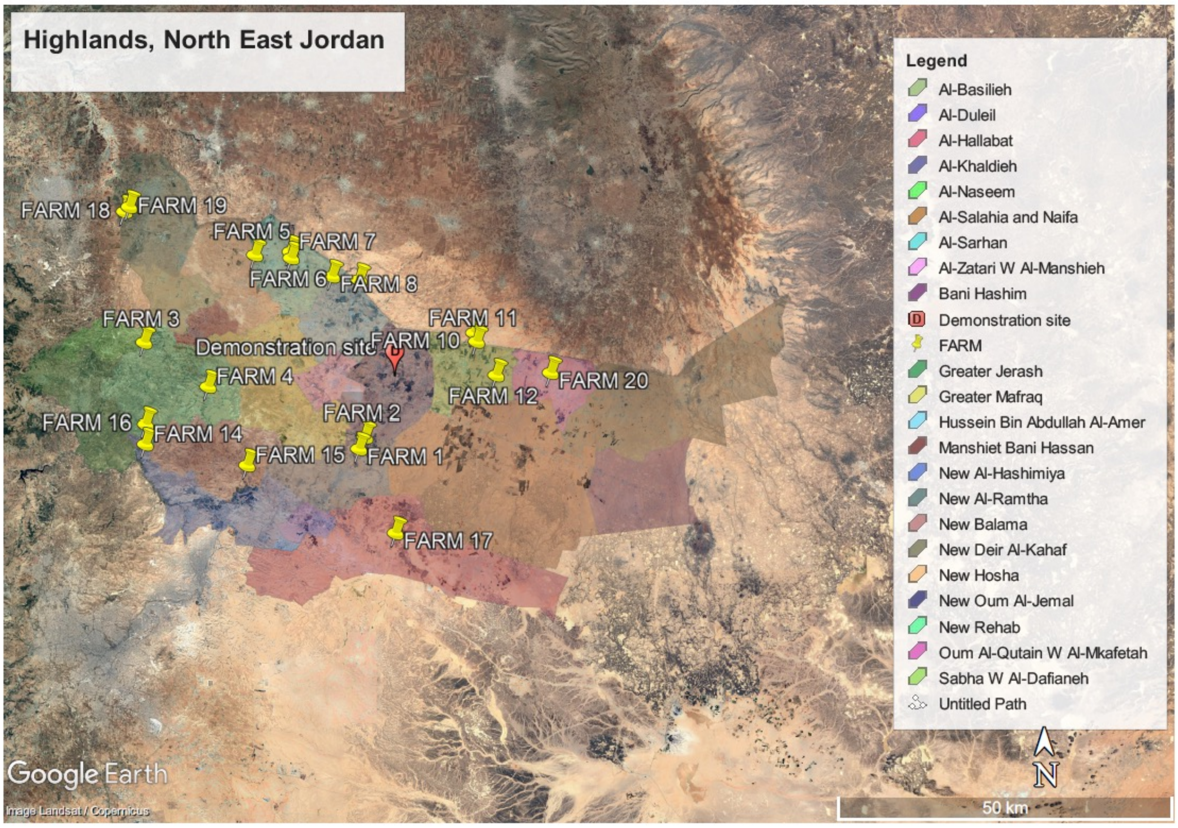

Figure 1: Locations of the rehabilitated farms and the demonstration site
Map generated through Google earth, Image land sat / Copernicus, 2022.

2.3. Categories of the rehabilitated farms

The twenty selected farms were categorized according to the adopted farming systems in the project areas. these categories are:

1- Open-field farming

2- Protected farming (in soil)

3- Protected soilless farming

4- Mixed farming (open field and protected farming).

Following this categorization, the twenty farms were categorized as exhibited in the below figure 2.

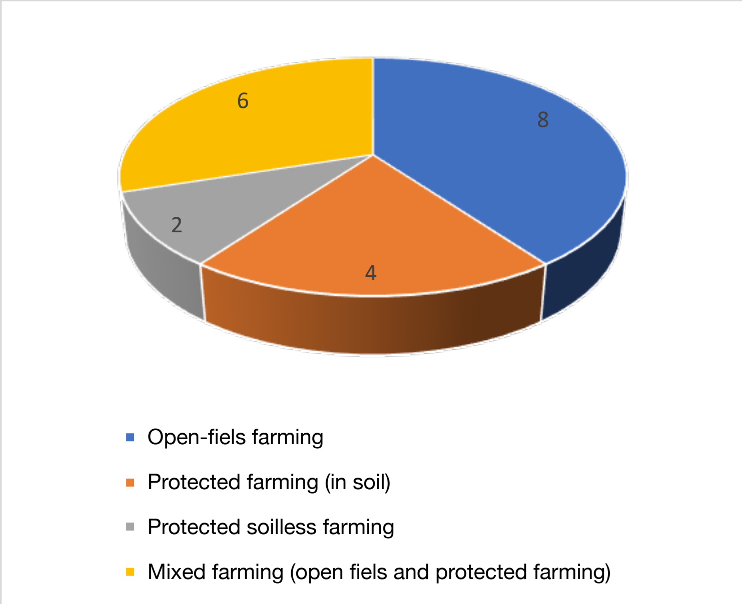

Figure 2: Numbers and categories of the rehabilitated farms
By report authors

It should be highlighted that the area of the selected farms lied in a range of 5–100 dunams (1 dunam = 900m^3), out of which the first category (open-field farming) comprised the largest areas, while the third category (protected soilless farming) comprised the smallest areas in this range.

2.4. Outcomes of (pre-interventions) technical evaluation

Overall, the utmost targets of the technical support to farms are basically enhanced water-use effeciency and increased farm productivity. Through replacement of deteriorated farming system components, these targets can be achieved, leading to expanded farming areas and additional job oppurtunities. Furthermore, tailored farm management guidelines were designed for each farm, considering water quality, soil health, previous cropping patterns, and other farm-specific conditions. All in all, the added value for each farm comprised a combination of hard as well as soft interventions.

However, such an approach is not a straight forward task, since the exisiting farming system components that rehabilitation intervensions will be built on are questionable, and farmers have a high interest in the short term benifits. Prior to implementation, farming system components were technically evaluated to specify the needs of each farming system, then setting priorities for each need. Following such an approach enables the comparison between different scenarios; entire farming system components were covered, such as agricultural water storage ponds, fertigation units, water pumps, water filters, irriragtion pipelines, etc. Likewise, farm management practices were taken into consediration based on semi-structured interviews with the farmers in addition to field observations. Besides, certain water and soil quality parameters were tested either on-site or in a specialized laboretary, depending on the parameter.

a. Agricultural water management

The visited farmlands had diverse layouts and water systems; the majority of farmers (80%) relied on ground water wells as the main source for irrigation, while the rest relied on water supply from the the Water Authority of Jordan (WAJ), treated wastewater, and water delivery tankers. Some farmers are still adapting to changing water costs and other factors by changing the water sources. Many farmers (60%) had a groundwater well within the farm, while others had off-farm water sources. Water storage techniques were also different among farmers (Fig. 3). All but one of water storage ponds had large surface area (>1,000 m^2) with over 3,000 m^3 capacity.

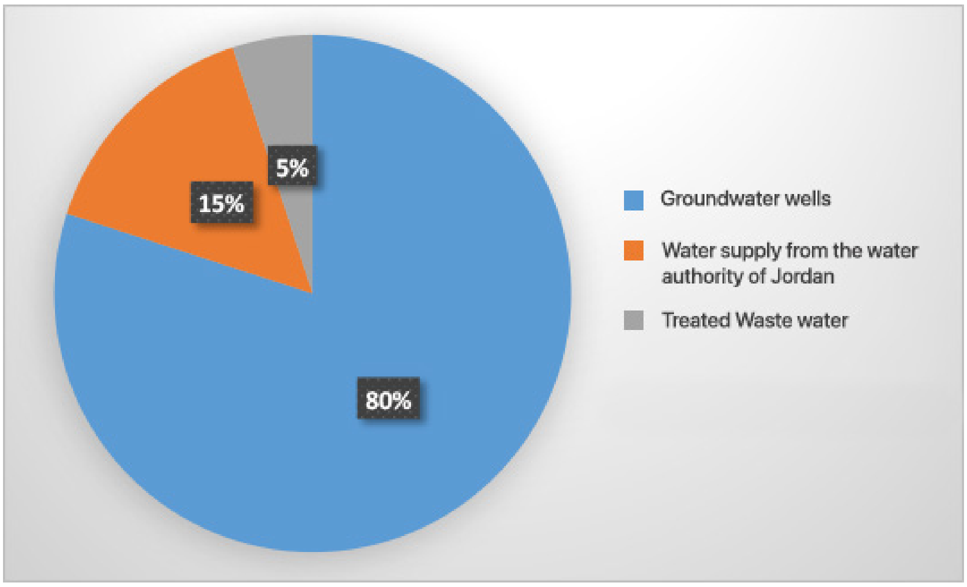

Figure 3: Irrigation water sources in the twenty farms
By report authors

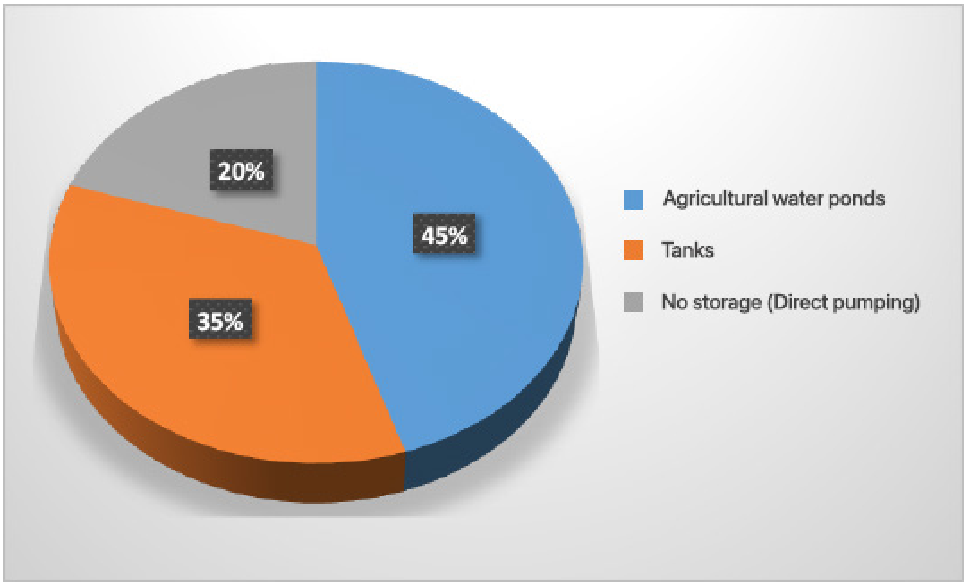

Figure 4: Water storage in the twenty farms
By report authors

All farmers adopted micro-irrigation systems, including drippers and sprinklers. The majority of farmers (80%) had a suitable irrigation layout for the desired crop production, while 20% did not. It was not possible to precisely determine farmers' water consumption rate; this was because farmers did not record their monthly water consumption. Instead, farmers were only interested in determining their seasonal water costs, which are related to varying water costs and pricing systems.

Although farmers' estimations of their water costs, water pricing, and water consumption were not consistent, it was estimated that farmers' monthly water consumption was generally over 200 m³/dunam for irrigation, while their monthly crop water requirement was estimated to range between 50 and 250 m³/dunam depending on crop type, growth stage, cultivation system and location, this was consistent with previous investigations done in the study area.

Generally, the primary cause of reduced water use efficiency in most farms was the deterioration of the irrigation system components; this mainly included the lateral irrigation lines, and also the main pipelines, and also water pumping systems to a lesser degree. Causes of reduced water use effeciency are demonstrated in the below table, it can be concluded that the reduced water use effeciency in each farm had at least one cause.

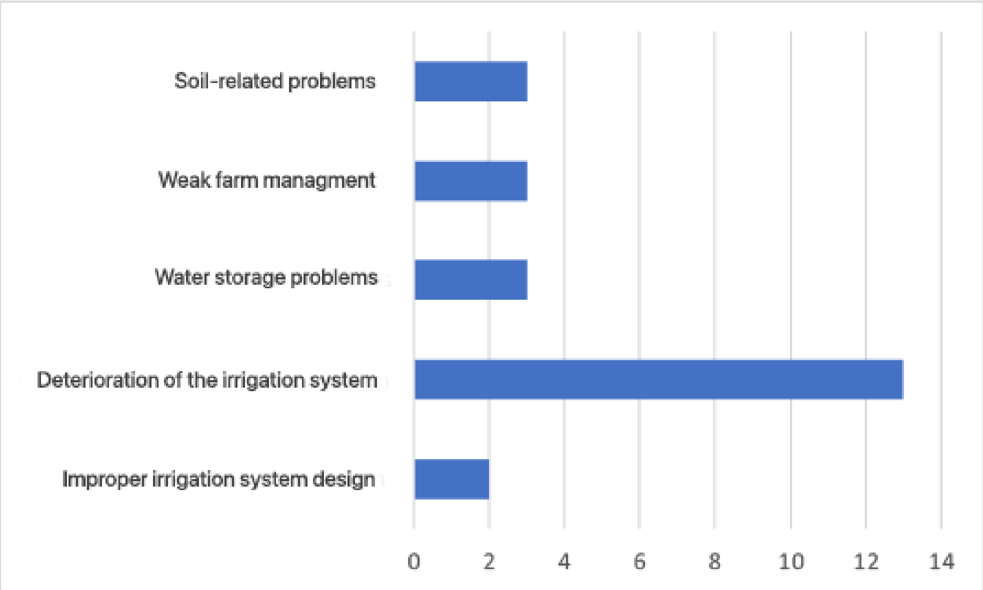

Figure 5: Causes of reduced water use effeciency in the twenty farms

By report authors

The deterioration of the lateral lines was indicated by poor distribution uniformity (ranging between 40–90%), and notable blockage at many emitters and throughout many lateral lines. The deterioration of mainlines (Fig. 5) and the water delivery system was indicated by notable leakage and during observation. Drip irrigation systems with good conditions can be presumed to have an irrigation efficiency of 80–90% 14, however, the systems evaluated in many farmlands in the project can be estimated to have irrigation efficiency well below 70%.

Poor irrigation design in some farms comprised an inadequate layout of the lateral, main, and submain lines. Whereas, water storage problems were mainly related to deterioration of the water storage pond (Fig. 6), particularly the plastic lining placed at the bottom and sides of water ponds, leading to leakage and deterioration of water quality. With regards to poor management, this involved mixing manure in the water storage pond, and neglecting irrigation for extended durations. Soil-related problems included poor drainage and excessive salinity; increased salinity increases osmotic potential in the soil and thus reduces water available to the plant roots, or increased water requirement for leaching.

Figure 6: Observations from the evaluated farmlands indicating deterioration of irrigation system components

All photos: © Smart DESERT project team

Figure 7: Deteriorated plastic linning in water ponds that are used for irrigation water storage

All photos: © Smart DESERT project team

b. Farming systems and crop yield productivity

As mentioned in section 2.3, the twenty farms were categorized according to the adopted farm system to open-field farming, protected farming (in soil), protected soilless farming, and mixed farming (open field and protected farming). Crops produced by the farmers included fruit trees, olive trees, field crops, and vegetables such as eggplant, pepper, and cucumber. Many farmers had two types of production systems within a single farmland (mixed farming), generally being plastic houses and open fields, and some relied on rainfall as supplementary irrigation source for growing winter vegetables and field crops.

Figure 8: Different crop production systems adopted by farmers

All photos: © Smart DESERT project team

Financial returns are difficult to correlate with crop production due to varying market prices and fluctuation of costs. However, some indicators of reduced crop yields had been noted (Fig. 8), and it is believed that productivity of these farmers are relatively low or significantly below optimal yields. Several factors were identified as the probable causes for reduced crop production, along with other factors related to inability to fully utilize the land for optimal crop production, these where categorized as shown in table 1.

Figure 9: Physiological indicators related to water stress, nutrient imbalance, and environmental stress

Table 1: Factors related to reducing crop production below its potential

Factors related to reduced crop production	Number of farms	Details
Water availability	1	Insufficient water quantity for utilizing the land for optimal crop production
Irrigation system problems	13	Problems related to the irrigation system components
Abiotic factors	15	Environmental factors such as temperature or soil-related problems

As demonstrated, the primary factors related to reducing crop production were irrigation system problems and environmental problems. As a primary example, poor distribution uniformity of the irrigation system can either cause variability in crop quality within the same field, or can negatively affect the entire crop if irrigation efficiency is very low. Environmental problems comprised plant stress from temperature extremes within greenhouses that lacked proper plastic cover, in such instances farmers grew crop types that required greenhouses for protection from temperature extremes, but had not been able to change or install new plastic covers; this had likely significantly reduced crop yields below its potential. Also, soil related factors were noted, which included either increased salinity or alkalinity, or both in some farmlands. Increased salinity has a well-established impact on crop production, and can be calculated using a yield reduction formula, and it could be be related to irrigation problems noted in the farms, while all irrigation water on-site tests showed acceptable (TDS) levels (300–900 (PPM)), therefore, acceptable salinity levels.

c. Soil characteristics

Soil samples were taken from each farmland, and the results indicated that farmlands had different soil types, but none had course textured soils; a description of soil texture and related characteristics are shown in table 2. With regard to slope, only two farmlands were on considerable slope (> 5%), which had planted trees exclusively. Most farmers had clear tilled soils, while only two farmers had soils with considerable surface stones. Some farmers were also noted to have a weed problem which they reported to be taken care of periodically. Alkaline soil, which is common in Jordan, was also noticed in all farms (Table 3) which reduce nutrients' availability to plants. Different levels of salinity were also observed in different farmlands (Table 4).

Table 2: Soil texture and related characteristics in different farmlands within the project

Soil texture*	Water movement	Water holding capacity	Aeration	Nutrient's retention	Number of farmlands
Clay and clay loam	Slow	High	Poor	High	**8**
Silty clay loam, silt loam, loam, silt	Medium	Medium	Medium	Medium	**10**

Table 3: Soil PH in the evaluated farmlands

Soil PH	Notes	Number of farms
> 8	Many micro and macro nutrients are unavailable to plants	12
7 - 8	Some micronutrients are unavailable to plants	6

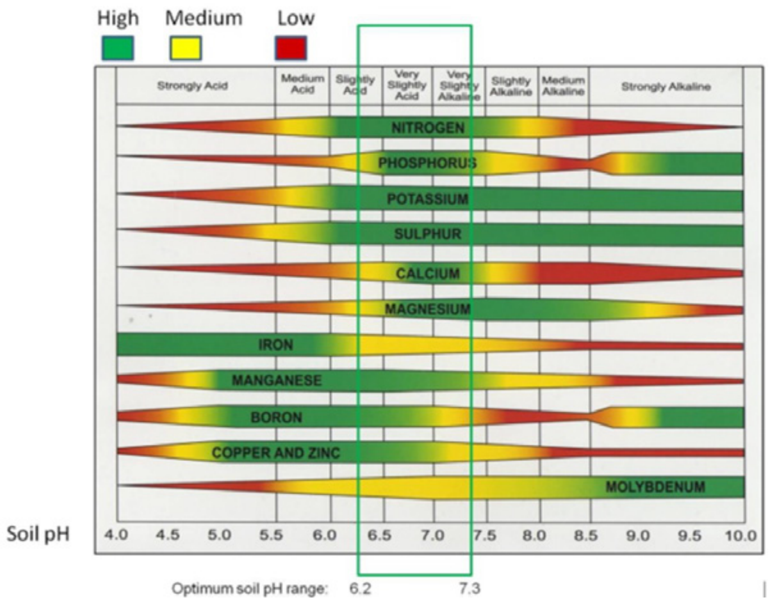

Figure 10: Soil PH and availability of plant nutrients

Source: UNIVERSITY OF CALIFORNIA (UCANR) https://ucanr.edu/blogs/SBMGBlog//blogfiles/89239_original.png

Table 4: Soil Salinity in the evaluated farmlands

Soil Salinity* (dS/m)	Salinity classification	Number of farms
0–4.5	Non-saline	11
4.5–9	Slightly saline	3
9.0–18	Medium saline	2
Higher than 18	Highly saline	1

*Soil texture testes were conducted in certified laboretaries, however, Soil was not analyzed where soilless systems were the sole production system.

Source of classification: https://www.fao.org/3/r4082e/r4082e08.htm

2.5. Technical interventions

In order to achieve the utmost targets of the technical support to farms (enhanced water-use effeciency and crop-yield productivity), a set of interventions were applied ; these are summerized in the below table, followed by figuers demonstrating samples of the implemented interventions.

Types of intervention	Expected outcomes
Installing, extending, or replacing the irrigation system, or specific components of the irrigation system (storage pond, lateral lines, mainlines, fertigation system, water pumps)	• Increased water use efficiency • Improving irrigation efficiency • Reducing water losses • Improved crop production • Improved distribution uniformity • Allowing meeting crop water requirement and reducing the risk of crop failure
Rehabilitation/installation of greenhouses	• Reducing risk of crop failure from environmental stresses • Improving crop yields
Recommendations and guidelines	• Irrigation system and water management • Soil fertility management • Monitoring crop yield and plant health indicators • Recommended crops based on local demand • Practices for greenhouse management and maintenance

Figure 11: Farm components before (top) and after (bottom) rehabilitation activities including replacement of water pump, water filter, fertigation unit, and the plastic cover of an agricultural water pond.

Figure 12: Farm components before (top) and after (bottom) rehabilitation activities including rehabilitation of greenhouses and an agricultural water pond

Figure 13: Sample of the installed greenhouses and irrigation networks

Figure 14: An agricultural water pond before (left) and after (right) rehabilitation

All photos: © Smart DESERT project team

Figure 15: Sample of the installed irrigation networks for expansion of a farmland (planted with turnip and beet)

All photos: © Smart DESERT project team

Figure 16: Sample of the installed irrigation networks for expansion of farmlands (planted with olives)

All photos: © Smart DESERT project team

2.6. Expected enhancements

As previously mentioned, the technical support is anticipated to result in enhanced water-use effeciency and increased farm productivity. However, as 'hard' components are not enough as stand-alone support, farm management practices are pivotal in the overall farming process. Therefore, the 'soft' component of the support is providing each farmer with tailored guidelines for his/her farm and considering water quality, soil health, previous cropping patterns, and other farm-specific conditions. Overall, the technical support component, as a whole, is meant to contribute to the key objectives of the project, namely increased year-round income, and improved work conditions. Therefore, the technical support was designed and implemented in such a way that economically empowers Syrian refugees and vulnerable Jordanians in the agricultural sector.

From the farmer (employers) side, the support is meant to increas his/her revenue through increased farm productivity and lessened water consumption which means lower costs. In this regard, to enhance export potential, the project consortium will build the capacity of participating farmers on the Hazard Analysis Critical Control Point (HACCP) standards and quality measures required to access key markets in Europe and Gulf countries. At this end, marketing component is pivotal in the Smart DESERT project, since there is a notable gap between the smallhold farmers and the agricultural markets; this issue will be adressed in section 4.

a. Water savings

As previously mentioned, the results of the pre-implementation technical evaluation showed considrable water losses due to deterioration of certain irrigation system components in some farms, while in other cases, expansion of the cultivated area had the highest priority. In order to minimze the water losses, deteriorated irrigation system components were replaced by brand new irrigation system components. The replaced components mainly comprised the linning of agricultural water ponds, water pumps, irrigation pipelines, fertigation units, water filtration systems, and emitters. Theoritically, assuming the same farm management schemes, the calculated water savings are summerzied in figure 17.

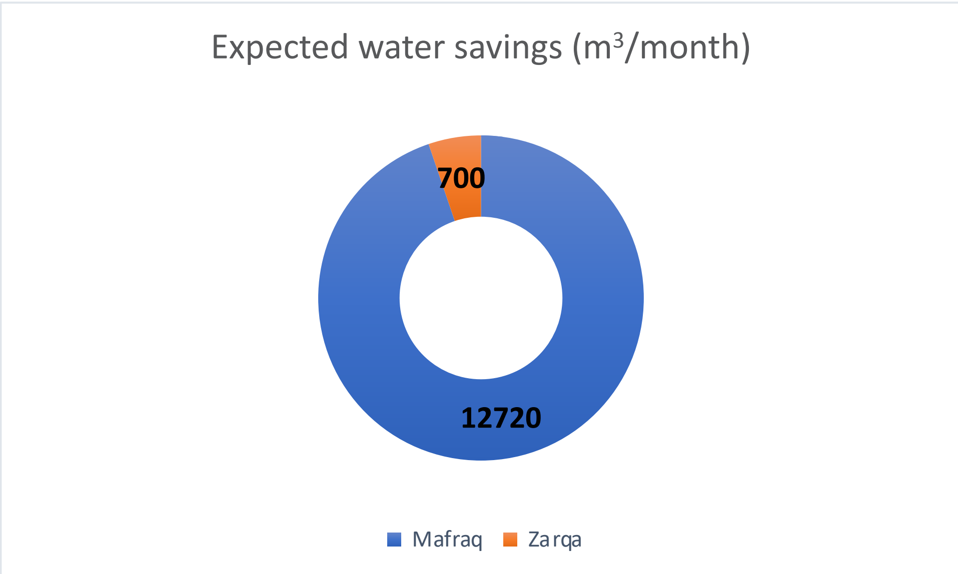

Figure 17: Expected water savings due to rehabilitation of deteriorated irrigation system components

By report authors

b. Farm productivity

As a pivotal outcome of the Smart DESERT project, the importance of increased farm productivity is not only about contribution to food security, but also creation of job oppurtunities for Syrian refugees and vulnerable hosting communities. Expansion of farmlands was achieved either through expansion of the existing irrigation network (for open-field farming), or by installing greenhouses (for protected farming). In this regard, its notable that most farmers were into protected farming, since greenhouses can considerably tackle the impacts of climate fluctuation, heat waves, and droughts. The exact areas expanded and expected farm productivity due to this expansion, are exhibited in the following figures.

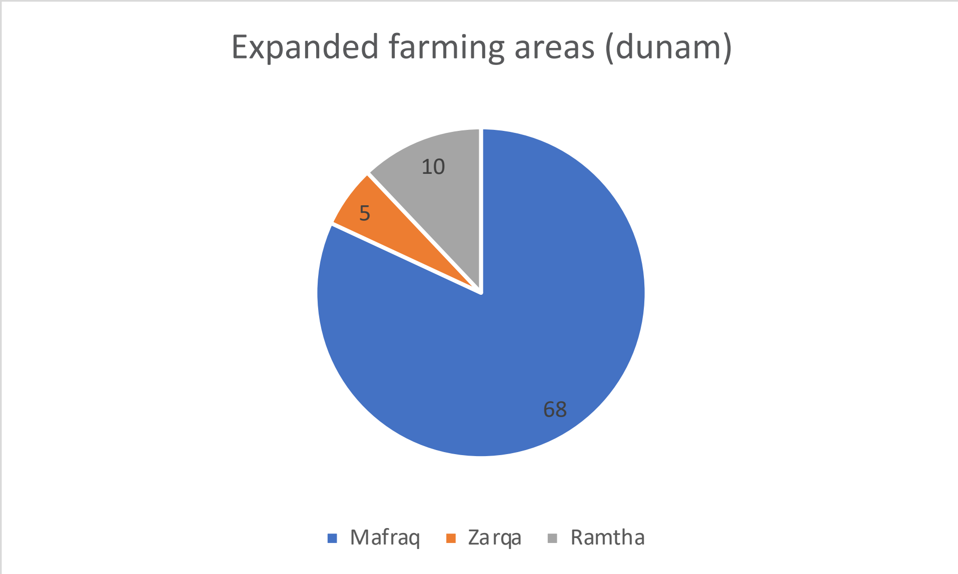

Figure 18: Expected expansion in farming areas due to rehabilitation intervensions

By report authors

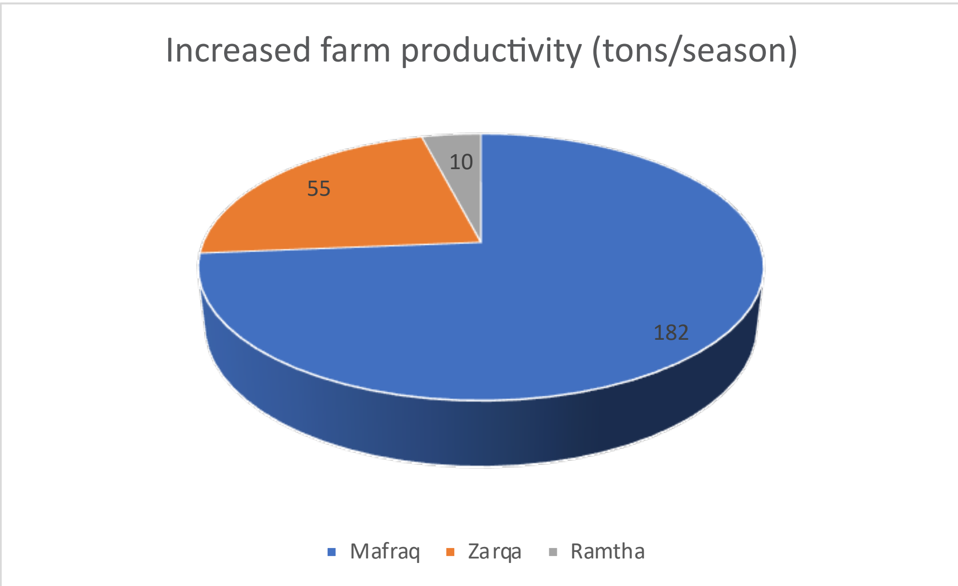

Figure 19: Expected increaments in the prodcitivity of the rehabilitated farms

By report authors

c. Created job oppurtunities

As previously mentioned, the implemented interventions enabled hiring additional labors in the project area, although a large proportion of the labors were hired temporarily (14–30 days). This is unavoidble in the agricultural sector due to seasonality. More specifically, labors whose expertise is on harvest, are only required to work during the harvest days, and so on. As a whole, the hired labors as an impact of this component of the smart DESERT project are summerized in figure 20.

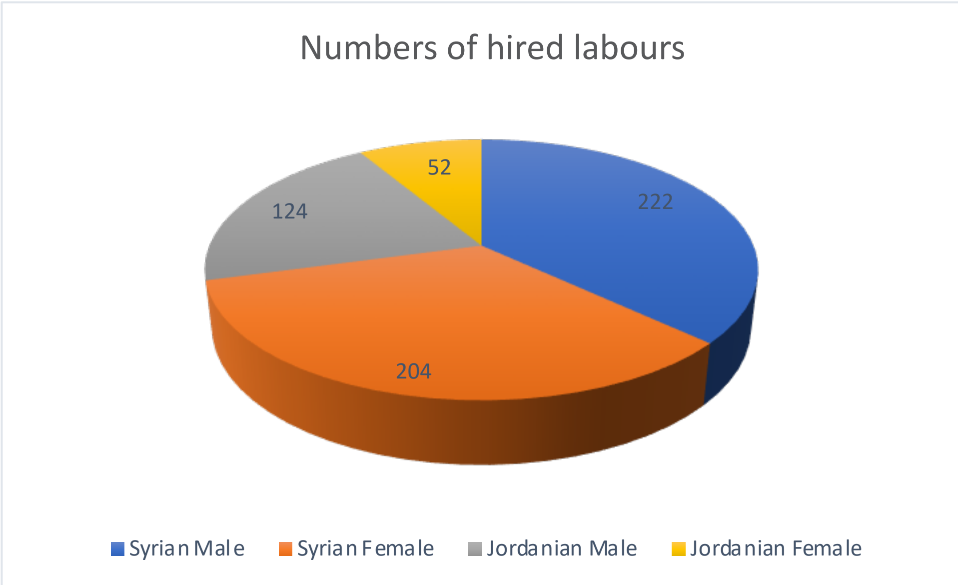

Figure 20: Overall numbers of hired labors in 2021, disaggregated by nationality and gender

By report authors

Photo credit: Smart DESERT project team

3. Demonstration site

As part of the Smart DESERT project, a demonstration site was established to showcase state-of-the-art agricultural techniques and systems. Farmers are invited frequently for the demonstration site to get the know-how in operating and sustaining these systems. In addition, grasping the monetized benefits of these systems can never be presented for a farmer in a place better than the farm itself. Due to the well-pronounced impacts of climate change, business as usual scenario is no longer an option, systems like solliess farming and aquaponics are of high importance as climate change adaptation measures and therefore climate-smart agriculture.

The demonstration site is located in Um Al-Jemal in Al-Mafraq governorate within the coordinates 32°18’56.09”N, 36°23’35.54”E. This demonstration site represents a field school targeting several categories from the local community. These will include farmers who will get hands-on farming practices and techniques. In addition, fresh graduates also can benefit from demonstration site through field visits aim to showcasing modern agricultural techniques. In the demonstration site, various agricultural techniques were implemented, these include:

- Aquaponic agricultural system: This system includes breeding of fish in the agricultural pond; providing economic benefits for the farmers and will increase the organic content in the irrigation water which in turn will reduce the use of chemical fertilizers. However, oxygen levels in the pond should be frequently monitored, and a precise feeding programm is also a crucially important aspect.
- Hydroponic agricultural system: This system is a 9m * 46.5 m low-technology greenhouse system comprising 6 channels and filled with volcanic tuff. The tuff ensures a good drainage of the irrigation water. This system reduces water consumption due to decreasing in evapotranspiration rate (water consumption of each greenhouse is approximately 1 m^3/day). This system also increases water use efficiency and reduces diseases in plants. This system will rely on the aquaponic system (figure 21) as an irrigation water source where water will flow through a fertigation unit that comprises three mixing tanks.
- Automated irrigation system: In a certain plot in the demonstration site, the irrigation system is fully automated. The system contains root sensors that measure soil moisture, nitrogen, phosphorus, and potassium content (NPK) in soil, based on these readings; the system will be automatically activated if soil moisture or water content in soil becomes below a certain threshold, depending on the growth stage of the crop and weather conditions.

Figure 21: The implemented systems at the Smart DESERT's demonstration site

All photos: © Smart DESERT project team

Photo credit: Smart DESERT project team

4. Market linkages

Due to competition with large farms, small farmers primarily sell product to local markets at relatively low margins, as well as to small agro-processors. However, rising production costs threaten the viability of processing industries and have led to the closure of all tomato-processing plants. Rehabilitating and supporting such facilities would therefore yield substantial multiplier effects on the small farms supplying them. Furthermore, linkages to export markets would not only improve the economic outputs of small farmers, but also enhance quality and work conditions due to the strict standards required by these markets. Therefore, as part of the Smart DESERT project, a project spin-off company was established to bridge the gap between small farmers and markets, namely the Smart DESERT Company (SDC).

The approved vision of the project includes creating a private sector off-taker that would connect project beneficiaries (farm-owners, industrial facilities, HBBs) with market buyers. The company will also enter into public-private partnerships that align with the project goals and will undertake some activities such as sorting, branding, storing, and packaging to meet market requirements.

Furthermore, the company will act as an intermediary between project beneficiaries and market buyers; focus will be to implement the outcome of the completed value chain mapping study and updates thereto. It should be highlighted that any profits made by the company will be reinvested into activities that will benefit project beneficiaries. No profits will be distributed to company owners; the model will follow the below project vision.

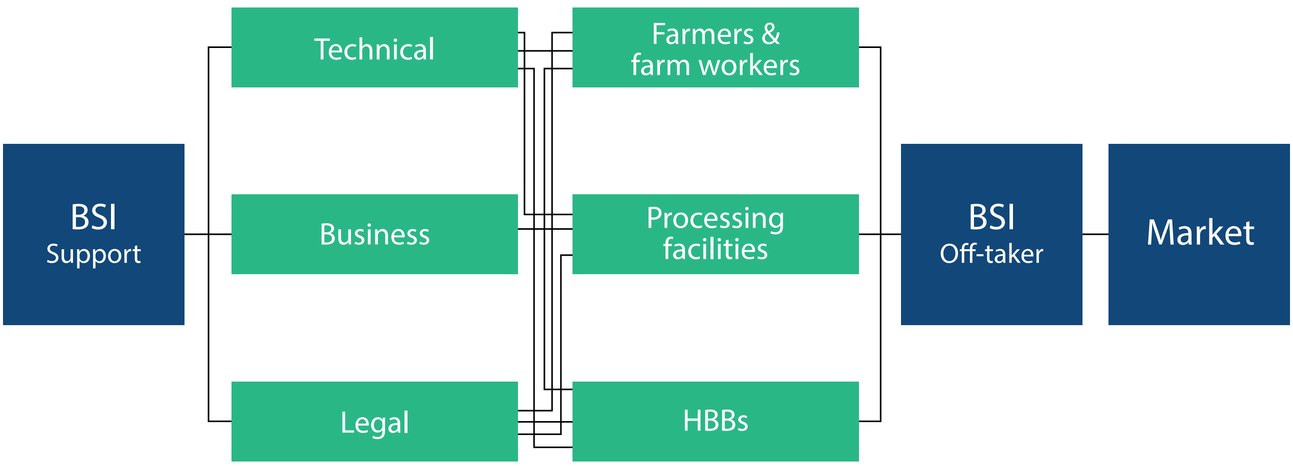

Photo credit: Smart DESERT project team

5. Lessons learned and ways forward

- There is a gap between the design and the exact needed quantities of materials for implementation due to varying site conditions such as topography, water availability, etc. Resolving this issue requires prompt actions and flexibility from the suppliers.
- Farmers tend to consult each other frequently; therefore, many farmers change certain farm components almost on a daily basis. These changes complicate the installation of the already ordered materials and require particular modifications.
- Polyethylene-based farm components such as irrigation pipes and plastic sheets are considered "consumables"; farmers usually purchase low-cost irrigation pipes and plastic sheets and, therefore, low quality.
- Building on an existing farm component is risky because the quality of the existing assets is not reliable and might minimize the benefit from the installed materials.
- Some farmers are not very sure about the crops they will cultivate in the upcoming period; this complicates installing the most water-efficient design of the irrigation network.
- Some activities require efforts and financial contribution from the farmer, such as cleaning a water pond to enable replacement of the deteriorated plastic sheets. These activities delay the implementation considerably and require intensive follow-up.
- Framers are highly interested in short term benefits, rather than-long term benefits; this might be attributed to the "post-pandemic" financial situation.
- A small part of each farm should be dedicated for on-farm trials.
- Although soil samples indicated medium to high salinity in three farms only, this number is expected to rapidly rise due unsuatinable farming practices and increased salinty of groundwater as a result of over abstraction.
- Capacity-building sessions are a need for farmers in regards to crop selection; modern cropping patterns such as intercropping are highly needed.
- Farmers had different distribution lines for their produce, some farmers sell to the central vegetables market, and some sell to local suppliers, with the latter option being more profitable.

- The majority of farmers did not have ownership of the land, but had rented the land via long-term leases.
- No farmers were noted to have on-farm production systems to make end products from their crops.
- The majority (90%) of farmlands visited were owned or managed by Jordanian citizens, while 10% were managed by Syrians.
- Jordanian farmers were very reliant on Syrian laborers, and describe them as "essential" and "extremely reliable". Some farmers even went as far as saying "their farms would shut down without Syrian laborers".

IUCN (International Union for
Conservation of Nature)
Regional Office for West Asia
Abdel Latif Salah street, bldg. 29 ,
Sweifiyeh, Amman, Jordan
T. +962 6 554 6912
www.iucn.org/westasia
www.iucn.org/resources/publications