SMALL SCALE IRRIGATION INFRASTRUCTURE DEVELOPMENT IN IRAQ: A FEASIBILITY REVIEW

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ABOUT IOM

The International Organization for Migration (IOM) is committed to the principle that humane and orderly migration benefits migrants and society. As an intergovernmental organization, IOM acts with its partners in the international community to: assist in meeting the operational challenges of migration; advance understanding of migration issues; encourage social and economic development through migration; and uphold the human dignity and well-being of migrants.

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ABBREVIATIONS AND ACRONYMS

BCM	Billion cubic meter
EDF	Enterprise Development Fund
EDFa	Enterprise Development Fund – Agriculture
EDFr	Enterprise Development Fund – Renewable Energy
FAO	United Nations' Food and Agriculture Organization
IOM	International Organization of Migration
MoWR	Ministry of Water Resources
PPM	Parts per million
SME	Small and Medium Enterprise
SCAS	State Company for Agricultural Supplies
TDS	Total dissolved solids
WUA	Water User Association

1. INTRODUCTION

1.1 BACKGROUND AND OBJECTIVES

The International Organization of Migration (IOM) manages the Enterprise Development Fund (EDF), which is a financing mechanism that provides customized financial support to small and medium enterprises (SMEs) for private-sector-driven job creation, economic recovery and development. IOM is currently working on the development of a model to fund businesses along agricultural value chains in Iraq, with regional focuses on the South, Centre, and Northwest of Iraq.

In this context, this study primarily provides a value proposition and business case for supporting the water and irrigation sector in Iraq, and aims to evaluate the viability of investments in individual water supply systems. The objective of this study is to assess the feasibility and economic viability of individual water systems, both as business opportunities for SMEs, and as a way to mitigate distress migration caused by slow onset environmental change.

The study primarily focuses on the status and prospects of individual water supply systems in Iraq, and more specifically in South of Iraq. It looks at the challenges, needs and context-appropriate solution and technologies in addition to the financial and regulatory environment related to water management, and the financial/ economic viability of improved irrigation technologies as a business opportunity for SMEs and as an alternative source of water for end users.

The water and irrigation sector is aligned with the overall strategic goal of IOM to support economic recovery through private-sector revitalization as the sector has relatively high demand for labour.

The aim of the study is to support small-scale irrigation infrastructure and identify the irrigation sector's needs and gaps. More specifically, the purpose is to:

- Identify key promising areas for supporting small-scale irrigation water sector for local economic development and decent job creation for farmers and SMEs.
- Identify existing gaps in agricultural water management to boost the revitalization of the sector development.

Many challenges should be taken into account, in particular the water availability that is mainly related to transboundary rivers and is not part of the scope of this study, in addition to large-scale irrigation infrastructure, climate change, drought and degradation in water quality. No single solution to all these issues exists, but investments in water combined with complementary policies and infrastructure development can bring a significant improvement in small-scale farming, poverty relief and economic growth. In brief, the study recognizes the opportunities for smallholder farmers and the private sector (suppliers), to be both a source of investments and to contribute to an environment where investments yield higher returns.

1.2 ENTERPRISE DEVELOPMENT FUND - AGRICULTURE (EDF-A)

IOM in Iraq launched the EDF in 2018, a financing mechanism to provide SMEs with access to capital to stimulate their recovery and growth and increase their demand for workers.

Since then, the EDF has supported 1,000 Iraqi businesses across the country to help create 4,975 jobs for men and women, returnees and host community members alike, in key economic sectors.

EDF Agriculture contributes to sustainable job creation through support to private-sector and human-capital development (with a focus on the agriculture sector) through delivering small grants to enterprises (including agricultural ventures) in targeted communities while also supporting SMEs.

1.3 COUNTRY AND ECONOMIC OVERVIEW

Agriculture is the second largest economic sector in Iraq, after oil. But the country is only able to farm about one third of its cultivable land because of water shortages, soil salinity and political instability, according to the United Nations' Food and Agriculture Organization (FAO).[1]

Agriculture remains the livelihood for most people across the country, but Iraqi farmers are faced with the reality that water supplies are quickly drying up and the quality of the available water is deteriorating. In fact, irrigated agriculture is dependent on an adequate water supply of usable quality. In addition to water quantities issues, water quality concerns, in particular the increase in salinity, is significantly affecting the water demand and the agriculture sector. Water that is saline becomes more difficult for plants to absorb and plants require substantially more water, which adds to a potential water table problem and makes long-term irrigated agriculture nearly impossible to achieve without adequate drainage.

Moreover, water demand is increasing not only for irrigation purposes, but also for oil recovery. Iraq has made impressive gains, nearly doubling the country's oil production over the past decade. But if the water demand is not met, production rates could struggle to climb much beyond their current levels.[2]

In comparison to the 1980s, there has been a more than 50 per cent reduction in the amount of precipitation. Climate change projections suggest that rainfall will decline over the twenty-first century, possibly by another 50 per cent. This drop is affecting agricultural production in the rain-fed areas and increasing pressure on water sources and agricultural systems that will need to be mitigated through improved water resource management.

1.4 GENERAL OVERVIEW

Agriculture is one of the most important sectors in Iraq after oil and gas. About 16 per cent of the country's area (7 million hectares[ha]), is classified as arable land, of which about 5.9 million ha are under-irrigated or rainfed cropping. Most of the country's irrigated agriculture is found in the central and southern governorates and is dependent on the Tigris and Euphrates rivers as the main water sources. According to FAO, about 64 per cent of cultivated land is irrigated.[3] Rainfed agriculture is more practiced in the northern governorates. Rainfed areas are significant producers of wheat and barley. Both crops are grown in the winter months from December to February and account for one third of national cereal production. While the same winter crops that are grown in the north are grown in the irrigated areas, farmers also produce rice, dates, cotton, vegetables, fruits, legumes and alfalfa.[4] Agricultural workers are estimated to make up 20 per cent% of the workforce in the country. However, agriculture is mostly practiced on small farming units, and it is a low input–low output system.[5] Low agricultural productivity has been a characteristic of Iraq's agriculture for the last two decades and has made the country dependent on imports to meet its domestic food needsTherefore, the recent policy directions in Iraq's development give priority to the agriculture sector, which is facing increasing threats of land degradation, desertification, water shortages and increased soil salinity – issues which will be compounded by the potential impact of climate change.

1 FAO. Country Programming Framework for Iraq 2018–2022; FAO & Ministry for Agriculture: Baghdad, Iraq, 2018.

2 IOM Iraq. 2021 IOM Iraq Return and Recovery Unit (RRU) Migration, Environment and Climate Change (MECC) Proposed Strategy.

3 FAO – Iraq. - Restoration of agriculture and water systems sub-programme 2018–2020.

4 FAO. Restoration of Agriculture and Irrigation Water Systems Sub-programme (2018–2020).

5 The Republic of Iraq Smallholder Agriculture Revitalization Project - IFAD.

2. WATER RESOURCES IN IRAQ

2.1 GENERAL OVERVIEW

Iraq lies in a water-stressed region with little water resources of its own, in an area experiencing interconnected political, economic, environmental and security challenges.

The Tigris and Euphrates rivers frame an area that is historically known as Mesopotamia, or "Land Between Two Rivers". The fertile banks of these two rivers and tributaries were the land of many great civilizations throughout history. Today, however, water conflicts between basin riparian countries in addition to environmental degradation and resource depletion have jeopardized the basin's safety and sustainability, creating migration problems in Iraq and affecting food security. The Tigris and Euphrates rivers originate in the Taurus mountains of southeastern Turkey where they are fed with alpine snows, lakes and rains. From there, they diverge and run south through the arid plains of Syria and Iraq before converging again and flowing into the Arabian Gulf, with some contribution from tributaries originating in Iran. The Tigris meets the Euphrates at Qurna to create Shatt al-Arab.

The scarcity of water resources in Iraq can be attributed to two main reasons:

EXTERNAL FACTORS:

TRANSBOUNDARY RIVERS

According to the Mediterranean Institute for Regional Studies, Iraq is losing the bulk of its water resources. In 1933, water entering Iraq through the Euphrates River amounted to 30 billion cubic meters. In 2021, it was 9.5 billion cubic meters. As a result of the construction of the Ilisu Dam by Turkey, the discharge of the Tigris River into Iraq decreased from 20.5 billion cubic meters to 9.7 billion cubic meters. In parallel, Iran drained five Iraqi rivers, all of which are now dried up. The loss of the rivers led to radical changes in the biological and environmental systems in the region, prompting the uprooting and migration of the residents of dozens of Iraqi border villages.

CLIMATE CHANGE

The region, with its arid climate, is expected to be one of the most vulnerable in the world to the potential impacts of climate change.[6]

INTERNAL FACTORS:

Internal problems and related issues of water scarcity are related to mismanagement of water resources inside Iraq, overuse of water by inefficient irrigation systems, pollution of water resources by wastewater, and increase in water salinity.

In addition to the above, the marsh area requires rehabilitation. Marshlands, known as the Garden of Eden, cover an area about 15,000–20,000 km2 in the lower part of the Mesopotamian basin. Restoring the marshes requires a significant quantity of water (around 13 billion cubic meters -BCM).[7]

Moreover, oil recovery requires a significant amount of water.

2.2 TOPOGRAPHY

Iraq can be divided into four regions according to topography:

- The mountain region occupies 5 per cent of the total area of Iraq, restricted at the north and north eastern part of the country. This region is part of Taurus-Zagrus mountain range.
- Plateau and Hills region is the second region and it represents 15 per cent of the total area of Iraq. This region is bordered by the mountainous region at the north and the Mesopotamian plain from the south.
- The Mesopotamian plain is limited between the main two rivers, Tigris and Euphrates. It occupies 20 per cent of the total area of Iraq. This plain extends from the north at Samara, on the Tigris, to Hit, on the Euphrates, toward the Gulf in the south.
- Jazeera and Western Plateau, which occupies 60 per cent of the total area.[8]

6 AFED (Arab Forum for Environment and Development), "Impact of Climate Change on Arab Countries," 2009.

7 World Bank (2006) Iraq: Country Water Resources, Assistance Strategy: Addressing Major Threats to People's Livelihoods. Re-port no. 36297-IQ, 97 p.

8 Ansari N. et al. (2014). Present Conditions and Future Challenges of Water Resources Problems in Iraq.

2.3 CLIMATE

The climate is mainly of continental, subtropical and semi-arid type. Rainfall occurs from November to April in the mountain's region. The temperature ranges between 16˚C in daytime and 2˚C at night in winter, and 45˚C during July and August dropping to 25˚C at night.[9]

The annual rainfall in Iraq varies between 150 mm in the western desert and more than 1000 mm in the mountainous area in the north.

The long-term average annual precipitation in Iraq is 216 mm per year, with high variability across seasons and governorates.

2.4 WATER RESOURCES

2.4.1 Surface water

The Tigris and Euphrates rivers, with their tributaries, form the main surface resources in Iraq and together represent 98 per cent of the water resources in Iraq.

The Euphrates River runs inside Iraq with a length of 1160 km. The Tigris River's length is 1718 km. Shatt Al-Arab River is formed after the confluence of Tigris and Euphrates rivers at Qurnah in Iraq and has a total length of 192 km.

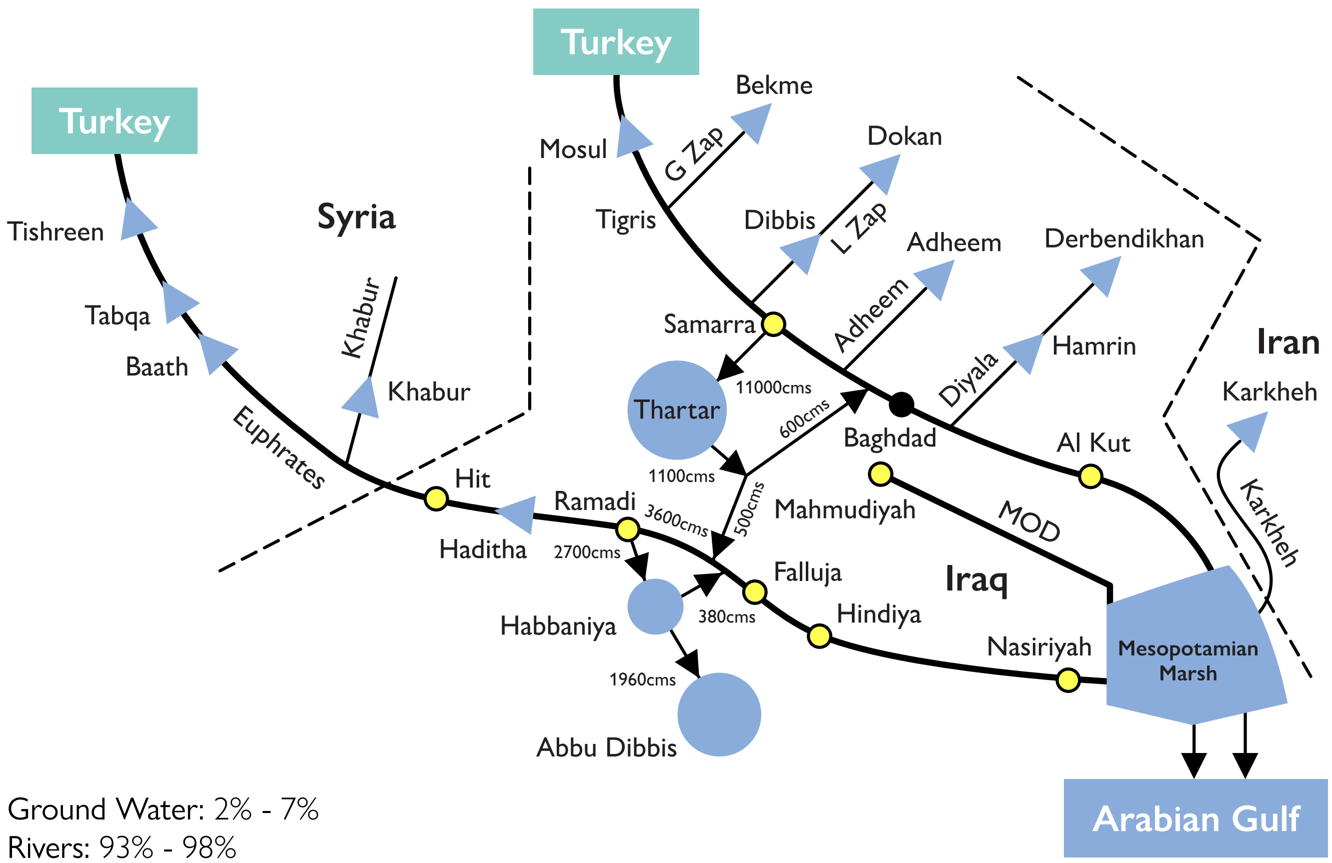

Figure 1 –Iraq's water sources[10]

9 Ibid.

10 Iraq Energy Institute(2018) Towards Sustainable Water Resources Management in Iraq.

The projected water balance shows a significant future water deficit.

Figure 2 – Water demand and fresh water available in Iraq

A 2018 analysis of water supply versus demand conducted by "Iraq Energy Institute" is based on the following assumptions:

- The oil Industry foresees a need of 1.773 BCM /year (by 2035).
- The marshes require a minimum of 5.305 BCM/year of fresh water.
- At least 50 m3/s needed to stop salinity intrusion from the sea to the Shatt Al Arab.
- Population is expected to grow to 60 million by 2035.
- Domestic consumption is forecast to increase from 4.6 BCM/year to 6.4 BCM/year by 2035.

The routing of the flows through the various dams built in Iraq and the neighbouring countries and the lack of common management practices show that the flows in Iraq do not coincide with the country's water needs. The peak flows arrive too late for winter crops and too early for the summer crops.

Prior to the winter season of 2021–2022, the Iraqi minister of water resources, Mr Mahdi Rashid Hamdani, stated that water coming from Turkey through the Tigris and Euphrates had decreased by 50 per cent. The Zab River in Kirkuk Governorate has decreased its water content by 70 per cent, and tributaries and rivers such as those reaching the Darbandikhan Dam (in northern Iraq) have reached zero. Hamdani noted as well that Iran has changed the course of many important rivers that flow into Iraq, such as the Sirwan River, which Iran has tried many times to drain. Iran has also changed the course of rivers in the border areas of Diyala and Khanaqin so they flow into Iran.[11]

11 Bahrooz Jaafar. The Water Shortage Crisis in Iraq, BESA Center Perspectives Paper No. 2,140, August 31, 2021.

2.4.2 Groundwater

Despite the large number of groundwater wells (both authorized and illegal), groundwater use in Iraq represents a minor percentage (5–7%) of the country's water resources despite its extensive use.

The quantity of the currently used groundwater is 3.77 BCM/year (88,000 wells).

2.4.3 Water quality and salinity

Geographic factors affect Iraq's water resources availability and use. The Tigris and the Euphrates carry large amounts of silt downstream. This silt is deposited in river channels, in canals and on flood plains. Drainage is complicated by the flat nature of the terrain, and this makes the plains prone to flooding and also provides relatively few sites for dams. The flat terrain facilitates irrigation, but also complicates drainage. Groundwater is not recharged completely and is high in salinity.

Total dissolved solids (TDS) is low in the north and in the western deserts, at approximately 500 parts per million (ppm), which is adequate for irrigation. But in general, the quality of water used for irrigation in the other regions exceeds the threshold of both Iraqi National Standards and World Health Organization guidelines.

During the mid-seventies, efforts were focused on implementing drainage projects to control salinity. The Iraqi government tried to reduce the salinity in the two rivers by constructing what is referred to as "the third river". This river is 565 km long and flows from Baghdad to the Gulf via the KhorZubair Canal. It was completed in 1992 after 30 years of works. It collects drainage water from more than 1.5 million ha of land between the Euphrates and Tigris rivers.

The salinity of the Euphrates at the Iraqi-Syrian border is 1250 ppm. The river gets progressively saltier as drainage water is added and as it passes through areas where groundwater leaks to the surface. Tigris River is in a better situation and TDS values at the Turkish-Iraqi border are 280–275 mg/l and reaches more than 1,800 mg/l in Basrah.[12] The situation is much worse on the tributaries where TDS values can reach more than 3,705 mg/l.

Iraqi soils and groundwater are not uniform in their salt content. In some cases, poor farming practices and lack or deterioration of drainage systems have led to high salt levels. In many locations, wells have been drilled into salty aquifers.

2.5 CLIMATE CHANGE AND SCENARIOS

Models of climate change indicate that the Middle East and North Africa is among the most vulnerable regions of the world to the potential impact of climate.[13] The effects of climate change, in particular the temperature increase, precipitation decrease , and water scarcity and salinization increase will exacerbate these challenges and have serious implications for Iraq's future. The World Bank foresees that by 2050, Iraq's climate will have undergone a transformative shift.[14] Annual average rainfall is projected to decrease by 9 per cent, with the greatest reduction of 17 per cent occurring during December, January and February. Rainfall intensity is projected to increase. The maximum amount of rain that falls in any five-day period (a surrogate for extreme storm events) is projected to decrease, as is the maximum period between rainy days. Runoff is also expected to decrease by 22 per cent (countrywide average). Mean annual temperatures have increased in Iraq by approximately 0.7 °C since 1950, and it is projected that the mean annual temperature will further increase by 2 °C by 2050. The frequency of heatwaves will increase, and heat stress is expected to occur at least once in the next five years. The number of frost days will decrease.[15] Along with higher temperatures, the occurrence of both sand and dust storms is also likely to increase.

12 Iraqi Ministry of Municipalities and Public Work (IMMPW) (2011). Water Demand and Supply in Iraq: Vision, Approach and Ef-forts, GD for Water.

13 USAID (2017). Climate Change Risk in Iraq: Country Risk Profile.

14 Iraq Climate-related security risk assessment – August 2018.

15 World Bank, 'Iraq dashboard: Climate future'.

2.6 LEGISLATIVE AND INSTITUTIONAL FRAMEWORK OF WATER MANAGEMENT

The Ministry of Water Resources (MoWR) is the sole entity responsible for water resource management in Iraq, as mandated by the Ministry of Water Resources Law of 2008. Its responsibilities include the efficient allocation, management, and development of additional water resources as well as safeguarding water quality. The Ministry is also responsible for the protection of Iraq's best interests in shared water resources with neighbouring countries. The Ministry carries out many of its functions through the National Centre for Water Resources Management, which exercises control through the operation of a complicated system of dams, reservoirs and hydraulic structures.

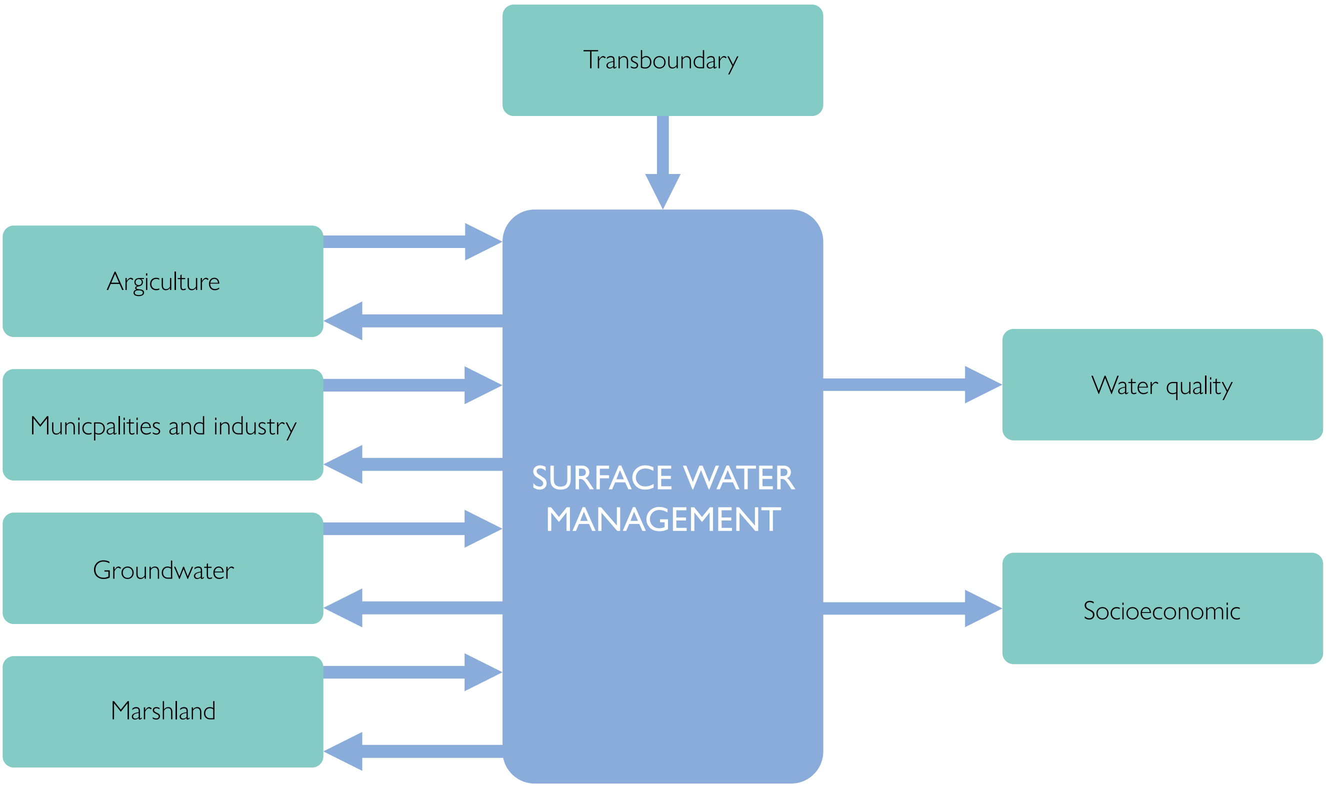

Figure 3 – Mandate of the Ministry of Water Resources in Iraq

Although the Iraqi Constitution includes laws that govern the establishment of water sector institutions, it does not include a more comprehensive Water Law that clearly indicates the objectives and responsibilities of the water sector.[16]

Despite the absence of a water law, other legal instruments are established to govern the sector. The Strategy for Water and Land Resources in Iraq and the National Development Plan of 2010–44, prepared by the MoWR, outlines the objectives of the water sector and covers the period up until 2035. Projects that address the challenges of water security and improvement of land productivity receive priority for investment, thus demonstrating the adoption of an integrated approach to water resources management. The National Development Plan includes a recommendation to establish a National Water Council that would assume responsibilities for management of water resources at national and transboundary levels, thus formalizing coordination mechanisms between relevant stakeholders in the sector.[17]

Of note, water tariffs in Iraq are extremely low compared to other countries.

16 World Bank. 2015. Public Expenditure Review of the Water Sector, Republic of Iraq. World Bank, Washington, DC. December.

17 Status of Water Sector Regulation in the Middle East and North Africa, World Bank Group 2017.

2.7 WATER MANAGEMENT STRATEGIES IN THE MINISTRIES

The Iraqi Ministries of Agriculture and Water Resources decided that the area planned for cultivation in the winter season 2021–2022 will be reduced by 50 per cent in comparison with last year, due to the lack of water sources. As quoted by the Iraqi News Agency (INA), the ministries stated that they have "approved the winter agricultural plan, with an area of 2.5 million acres, and a 50 per cent reduction compared to last year, due to the lack of water sources." Interviews conducted with the regional representatives of the Ministries of Agriculture and Water Resources during the field visits in Basrah, Missan and Thi-Qar revealed that this percentage will not be applied systematically in all governorates.

FAO[18] estimates that "by the end of the season, wheat production will be 70 per cent lower and barley production negligible." The Strategy for Water and Land Resources in Iraq includes several actions related to irrigation water management strategies:

- Rehabilitation of the irrigation system infrastructure: Several actions are listed.
- Rehabilitation of the irrigation canals (Tigris-Euphrates) to increase operational capacity from 100 m3/s to 250 m3/s.
- Rehabilitation of the drainage system.

The absence of an adequate national water management policy exacerbates and compounds these critical threats. Iraq has a water withdrawal rate (from surface water and groundwater sources) that is almost double the world average. In addition, the water infrastructure and irrigation system are outdated as they were built in the 1950s and 1960s and cannot respond to today's challenges.[19]

2.8 WATER MANAGEMENT AT THE FIELD LEVEL

Water Users Associations (WUAs) manage agricultural water. About 140 WUAs have been established in Iraq to date, with the direct support of the MoWR, and a water management structure is starting to take shape.

WUAs are generally well organized and effectively operated by farmers who know each other and are committed to cooperating closely to achieve common goals. Typical associations comprise up to 50 users who share a main canal or a branch canal. Such associations handle water allocation, operation and maintenance functions.

2.9 WATER MANAGEMENT ACTIONS

Actions to be taken are well known, and should be conveyed to the farmers in parallel with financial support to achieve:

- Better management of water for irrigation;
- Increased water use productivity and efficiency in rainfed areas and in irrigated systems;
- Canal rehabilitation and maintenance;
- More efficient on-farm water management techniques;
- Incorporation of water-efficient and drought-tolerant crops and varieties;
- Combined use of surface water and groundwater;
- Adoption of innovative irrigation management schemes by WUAs;
- Expanded reuse of treated wastewater.

18 Food Security in Iraq: Impact of COVID-19 with a special section on water shortages and adaptation (November 2020 - May 2021).

19 Iraq climate-related security risk assessment.

3. IRRIGATION SECTOR IN IRAQ

Irrigation, since the dawn of civilization about 7,000 years ago, has been key to agriculture in Mesopotamia, known as Iraq now. The Tigris and Euphrates rivers are renowned for their dramatic spring floods and tremendous amounts of silt they carry. Given that most of the plains of the country are very flat and poorly drained, the region suffered from persistent problems of poor soil, drought, catastrophic flooding, silting and soil salinity.

In the twentieth century, Iraq made a concerted effort to restore its irrigation and drainage network and to control seasonal flooding through the construction of several large dams and river control projects, the rehabilitation of old canals, and building of new irrigation schemes.

To increase water transport efficiency, minimize losses and water logging and improve water quality, a number of new canals were constructed mainly in the southern part of Iraq. The most important was the "Third River," which functions as a drainage water of more than 1.5 million ha of agricultural land. It was completed in 1992 with a total length of 565 km and a discharge capacity of 210 m3/s.

The agriculture sector is the main sector in consumption of water in Iraq. Water losses in irrigation schemes, all over Iraq, are substantial. By and large, water is conveyed to farmers' fields through very poorly maintained distribution systems made of canals and ditches, which suffer significant water losses because of infiltration, seepage and leakage.

FAO[20] (2012) reports that on-farm field application efficiency using the traditional surface gravity systems is assumed to be between 30–40 per cent but is probably near 20 per cent or less, and that it is possible to raise the total irrigation efficiency from 30–40 per cent to 60 per cent using modern irrigation methods (pipe irrigation, sprinkler irrigation, drip irrigation and canal lining).

There are three main sources of irrigation water in Iraq:

- Surface water (Tigris and Euphrates rivers and their tributaries): Recently, the water quality of the Euphrates has changed due to the decrease in the amount of water reaching Iraq. The decrease was from 14 BCM to 9 BCM. The salinity of the Euphrates increased dramatically from 300 to 400 ppm (about 0.5 decisiemens/m), while it has currently exceeded 1.1 decisiemens/m and reached 4.5 decisiemens/m in the city of Nasiriyah. Despite the increasing risks of salinity in the water of the Euphrates River, the water is still good enough to be used in irrigation[21]
- Rainwater: is a source for irrigation water in Iraq. The rain in Iraq is limited and the rainy season is very short. However, large agriculture areas in Iraq depend on rainwater for irrigation, particularly in the northern governorates. Many studies indicated that there is no clear strategic plan for an integrated management of rainwater resources. The water harvesting in Iraq could add thousands of cubic meters to irrigation water resources.
- Groundwater: Reserves of groundwater are distributed over 30 basins, most of which are located in the northern and central regions, while others are In in the Western desert region.

3.1 IRRIGATION DEMAND

A considerable portion of the agricultural lands in Iraq are under irrigation. Rainfed agriculture for grain and sheep production is practiced in the northern parts where the mountains, foothills, and Jazeera desert are located.

According to FAO, the total area used for agricultural production is about 8 million ha, which is almost 67 per cent of the cultivable area. However, due to limitations such as soil salinity, drought, shortage of irrigation water in summer, fallowing and the unstable political situation, it is estimated that the average area actually cropped each year is 3–4 million ha.

Agriculture in Iraq is primarily a winter cultivation. The summer cultivation is limited, and it usually located in the northeastern region of Iraq. The summer cultivation area is less than a quarter of the area of the winter cultivation. The crops vary from year to year in area and production, depending on the variation in rain and surface water. Irrigation is extensively practiced in the central and southern regions.

Agriculture is mostly practiced on small farming units. The landholding system in Iraq is a mixture of owner operator, lease holder (7.5–17.5 ha) and share cropper. The size of landholding depends upon the type of land. According to the agricultural reform regulations of 1990, the maximum holding size is 75 ha in rainfed area. State-owned lands (Amiri lands) are divided into two types: state-owned lands that have never been occupied and lands exploited by individual owners or cooperatives with an official land registration title.

20 Iraq (2012) Agriculture sector note – FAO Investment Centre.

21 Othman I. (2021) Analyzing the Effectiveness of Modern Irrigation Methods in Iraq.

Irrigation projects can be classified according to the area of the agricultural land:

- Large- and medium-scale irrigation: Irrigation projects in Iraq are identified as large-scale irrigation if the command area is greater than 200 dunm, medium if it falls in the range of 30–200 ha, and small if it covers less than 30 ha.
- Small-scale irrigation schemes: The small-scale irrigation schemes include mainly traditional furrow irrigation where farmers flow water down small trenches running through their crops, and recently some modern schemes built on their initiative, sometimes with government support through the State Company of Agriculture Supplies.
- Micro irrigation: individualized small-scale technologies for lifting, conveying and applying irrigation water.

3.2 IRRIGATION INFRASTRUCTURES AND ASSETS

Along the Tigris River, several large and small projects of irrigation have been built. The Euphrates River has several irrigation projects thatwere developed in the 20th century. Irrigation projects include several categories, such as dams, canals, drains, pumping stations, regulators and reservoirs. There are six large dams in Iraq, five within the Tigris basin, and one within the Euphrates basin.

Large dams include: Doukan, Darbendhikhan, Hemrin, Haditha, Mosul Dams, and Ad-haim Dam. Small and medium storage dams are scattered throughout Iraq. These dams can be found in three main areas:

- Mountainous region of Duhok, Erbil, Sulaymaniyah and Kirkuk governorates
- Easter valleys area in Diyala, Wasit and Missan governorates;
- Western area in Anbar, Najaf and Muthanna governorates.

For each dam, a complete irrigation system is connected such as canals (main, secondary, tertiary), regulators, pumping stations, and others.

During the last decades, the operation and maintenance of irrigation and drainage systems (i.e. canals and pumping stations) were severely affected. Outdated and damaged irrigation infrastructure has been operated for a long time without maintenance or proper management plans. Most pumping stations were built in the early 1970s and hundreds of large irrigation and drainage pumping stations are still in poor state. The primary, secondary and tertiary canal networks are also degraded due to lack of maintenance. Deterioration of canal linings, the outgrowth of weeds and sedimentation have reduced conveyance capacity significantly. Currently, the ministry of Water Resources started to conduct several rehabilitation and upgrading projects for the infrastructure components.

Figure 4 – Rehabilitation works conducted by the Ministry of Water Resources in Iraq

FAO estimated that less than one quarter of Iraq's area developed for irrigation is equipped for drainage. Many drains are blocked and many of the drainage pumps used for lifting effluents into the outfalls have broken down. Over-irrigation as well as drainage problems (silted canals, non-operational drainage pumping stations, etc.) have caused severe water logging and salinity problems in most of the irrigation schemes built between the Tigris and Euphrates rivers, causinga significant decrease in the yields of major crops affecting farmers' income. This is one of the factors contributing to the migration of rural populations to cities in search of employment.

3.3 TYPE OF IRRIGATION TECHNIQUES USED

The Ministry of Agriculture in Iraq adopted a programme to implement modern irrigation techniques in 1991, but implementation did not start until 2000. Three types of irrigation techniques were adopted: drip irrigation, sprinkler and central pivot.

There is no consistent inventory regarding the developed irrigation of the country.

Different irrigation systems are implemented such as:

- Gravity irrigation (flood irrigation, row irrigation),
- Sprinkler irrigation,
- Pivot system
- Localized irrigation systems (drip irrigation).

The site visits conducted in the southern and northen governorates and the discussions with farmers allowed to summarize the various types of irrigation techniques as follows:

3.3.1 Traditional surface irrigation

The technique consists in feeding the irrigation system from a regulation basin or directly from the exit of the drilling of the grooves or basins, through small channels or polyeth-ylene pipes. This technique was seen to be used in several areas, in the south and the north of the country.

In general, the old concrete channels are not fully waterproof and the replacement by duct above ground improves the distribution yields.

3.3.2 Distribution by surface or burried pipe

A very common technique in old orchards is the installation of polyethylene pipes of diameters 90–110 mm to replace the channels. Most frequently, the pipes of diameters 63 mm and 50 mm are connected downstream and constitute a telescopic network. These pipes on the surface, connected to a line of 16 mm or 20 mm are sometime equipped with one valve for each tree.

For recent and new installations, the main pipes are buried and sector valves are placed at the head of subplots. On other plots, less ergonomic, the principle remains the same as before with one little valve per tree.

3.3.3 Trickle irrigation

The previous equipment allows water to be distributed from a main duct but with no real control of the flow rate per tree. Some plots are equipped with crown drippers around the feet or fed by nozzles.

3.3.4 Irrigation of vegetables

Vegetable production is traditionally produced in gravity-irrigated basins. For more industrial crops such as tomatoes, drip irrigation with integrated drip ramps is developed. For greenhouses, different systems are present, sprinklers or drippers. Drip irrigation is also used for new palm orhards.

Irrigated project in Duhok.

Irrigated project in Duhok.

Irrigated project in Suleimaniyah.

Irrigated project in Erbil.

Irrigated project in Nasiriyah.

Irrigated project in Nasiriyah.

Irrigated project in Nasiriyah.

Irrigated project in Amarah.

Figure 5 – Irrigation types identified in the Southern and Northern governorates

3.3.5 Fodder irrigation

The plots are mainly irrigated by sprinkling either with one irrigation station, or for large plots, with several irrigation stations. The other technique is irrigation by central pivot for more recent implantation on large plots. For small areas, surface irrigation is carried out per basin.

3.4 Drainage systems

Before 1980, field drains (perforated pipe), collector drains and lateral and main drains as open ditches were constructed all over Iraq. Salinity reclamation and laser land leveling were previously part of an active field programme, but these were discontinued in the early 1980s when war priorities stalled most development efforts. In Iraq, the Third River, which was completed in 1993, acts as an outfall drain for the area between the Euphrates and the Tigris.[22] The canal was planned in 1956 to begin near Sammarra, some 70 miles north of Baghdad, and enter the gulf at the Fao Peninsula near Basrah. The main stem of the canal was nearly completed in 1990.

Most lateral and main drainage channels were choked with weeds. Some farm drainage systems apparently are clogged with encrustations and need to be rehabilitated or replaced.

Drainage water can be used for planting green belts to combat desertification and restoring deteriorated marshes and wetlands.

3.5 STATE COMPANY FOR AGRICULTURAL SUPPLIES

The Ministry of Agriculture's State Company for Agricultural Supplies (SCAS) is the State-owned company that provides financial support to Iraqi farmers to invest into equipment to work their land. Agricultural equipment is imported and publicly distributed to farmers by SACS.

SACS provides Iraqi farmers with subsidized equipment, irrigation systems (drip and central-pivot sprinklers), pumps, fertilizers, seeds, pesticides, plastic greenhouses and other equiment from well-known global and local origins. SACS has 17 branches in most Iraqi governorates.

Most of the products and equipments are imported, and are supplied to farmers for reasonable prices (below the Iraqi marquet price by 25–30%) or by installment payments over a number of years (4–15 years). The same equipments can be found in the market at a cheaper price but not with the same specifications and quality. The main problem that was highligted during the field phase is that the budget allocated for SACS is limited and cannot satisfy demand. Moreover, there currently is a shortage in irrigation products, specially for drip irrigation systems, in the SACS inventory. Only the central pivot sprinkler system is currently available. The Ministry of Agriculture is trying to increase efforts to supply the needs of SACS to ensure the production of the staple cereal crops, wheat and barley in order to maintain production.

22 H.P. Ritzema 2016 Drain for Gain: Managing salinity in irrigated lands – A review.

4. DATA COLLECTION

4.1 METHODOLOGY

The research methodology for this report is a combination of desk-based research and primary research through interviews with representatives of farmers or agricultural SMEs and government organizations, academic institutions and private sector trade bodies.

In addition to the interviews and site visits, the feasibility assessment involved the analysis of the EDF-a call for Expressions of Interest received in 2021–2022. Key Informant interviews and field visits were conducted in the three governorates in Iraq: Basrah, Missan and Thi-Qar during the period of November 26, 2021 till 3 December 2021, followed by a second field visit in February to Erbil, Sulaymaniyah and Duhok .

The stakeholders met in these governorates can be categorized as follows:

- Farm owners;
- Governement and public sector: MoWR (Water Resources Directorate, Water Users Associations, General Commission for Groundwater), the Ministry of Agriculture (General Directorate, Training department, State Company for Agricultural Supplies);
- Private sector: Irrigation suppliers, Chamber of Industry, Chamber of Commerce;
- Academic sector and univeristies, in particular the Faculty of Agriculture.

"Water", "salinity" and "cost" were identified as the biggest concerns: As water scarcity increases and wells are drying, the cost of water is becoming too high to afford, which is why many farmers are coming to appreciate the benefits of drip irrigation. But even with drip irrigation, the salinity of water is the most preoccupying and critical topic. In addition, the adopting water saving and water treatment techniques require a considerable initial investment that usually farmers do not have. In addition, the high cost of operation and maintenance (including cost of treatment consumables, cost of energy for pumping ...) was also highlighted.

4.2 EDF-A DATA

The EDF-a call for Expressions of Interest carried out in a limited number of governorates during the end of 2021 and beginning of 2022 is considered as a farmer survey in this report. The data related to the EDF-a call for Expressions of Interest received from the governorate of Ninewa, Basrah, Thi-Qar and Missan was analysed. The duration of the various calls and the method of community engagement affected significatly the number of applications. For this reason, Ninewa had the highest number of applications (5,748) , followed by Basrah, Thi-Qar and Missan.

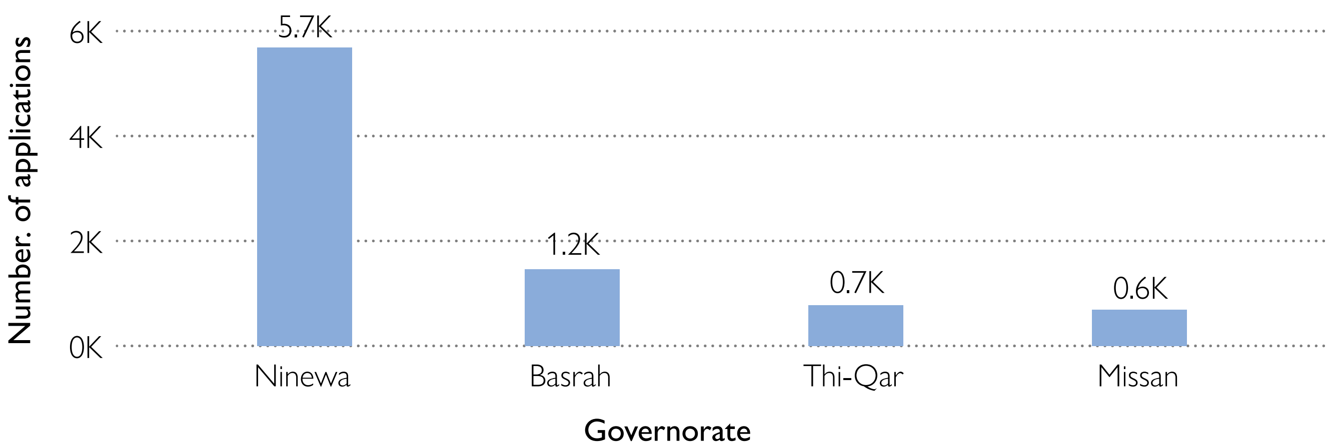

Figure 5 – Number of applications received per governorate

Only the applications received in each governorate requesting support for agricultural businesses (dark blue color), in particular for farmers, were analysed. It should be noted that these data are for EDFa and the call was not limited to small-scale irrigation infrastructure support only but to selected value chains in each of the governorates.

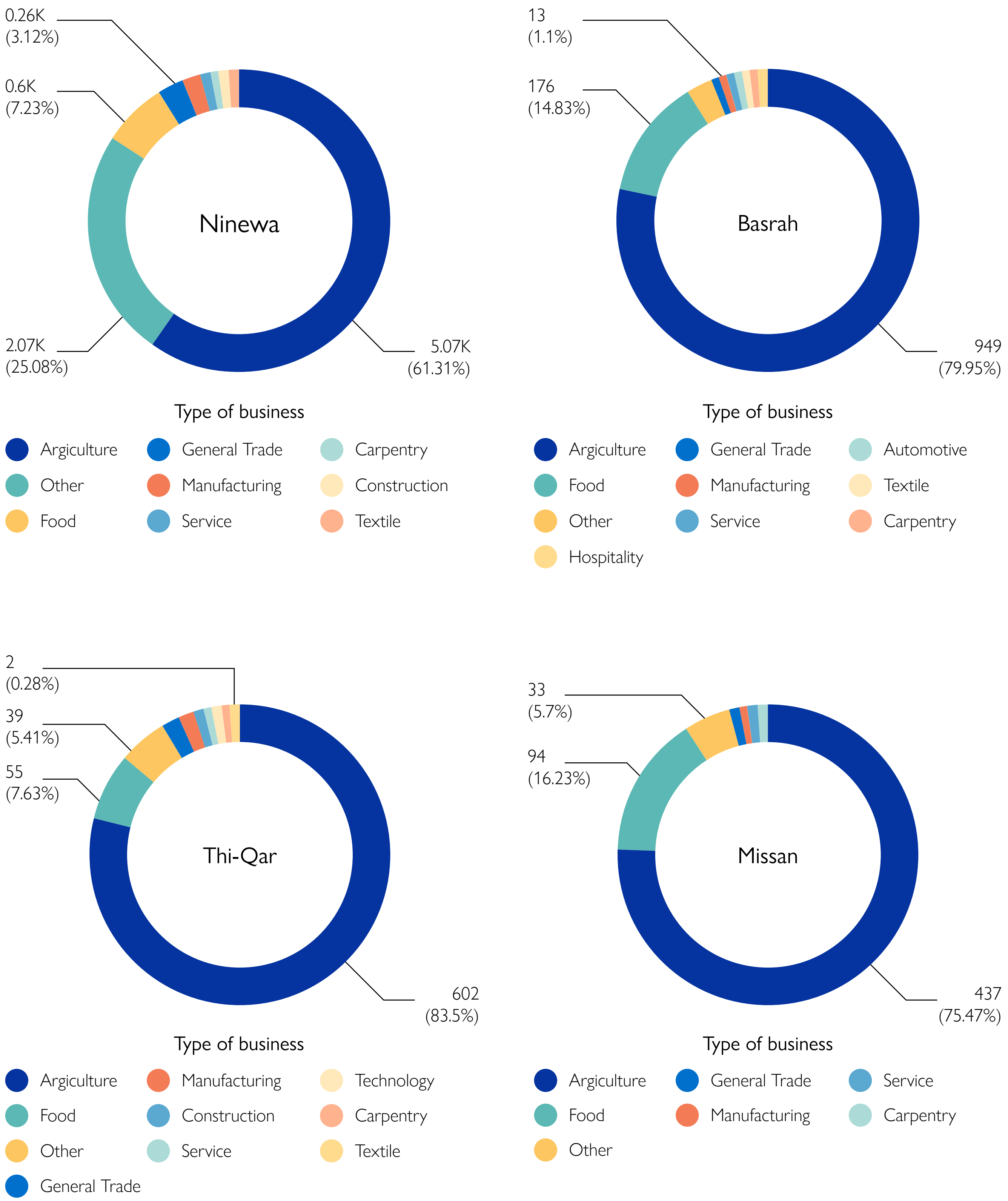

Figure 6 –Applications received per type of business requesting financial support

Farmers requesting financial support in the agricultural sector can be divided into two categories: farmers growing crops and those raising livestock.

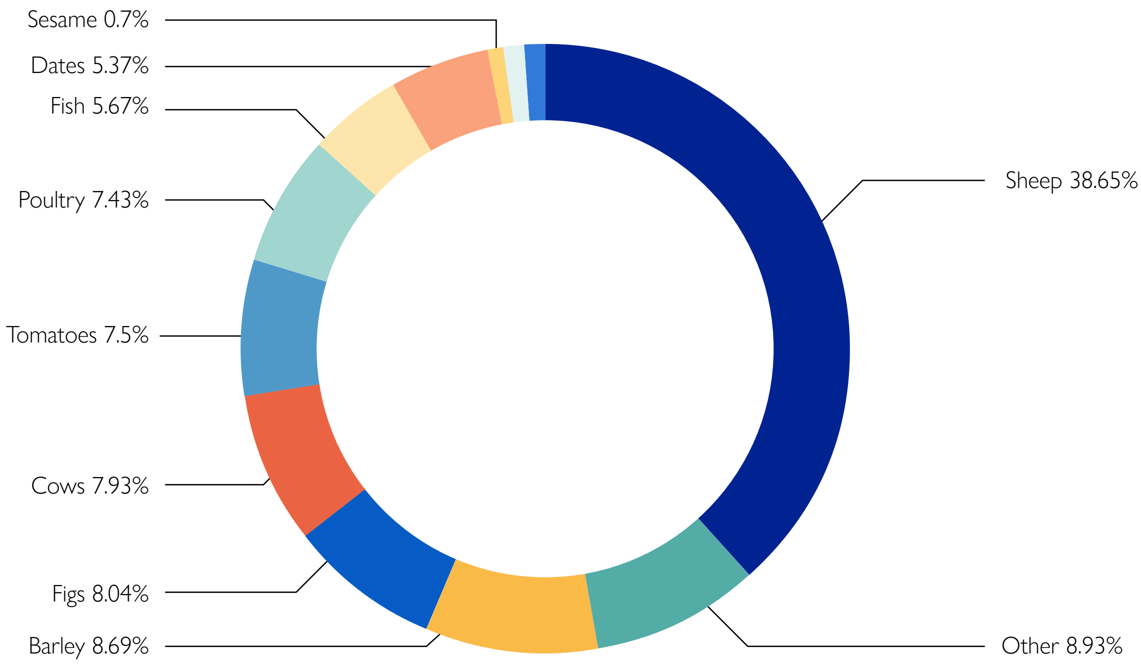

Figure 7 – Application received per crop type

Only the first category (farmers growing crops) will be further analysed in this study. The requests focused on the following type of budget supports: irrigation systems, power generation system, well drilling, and water treatment solutions:

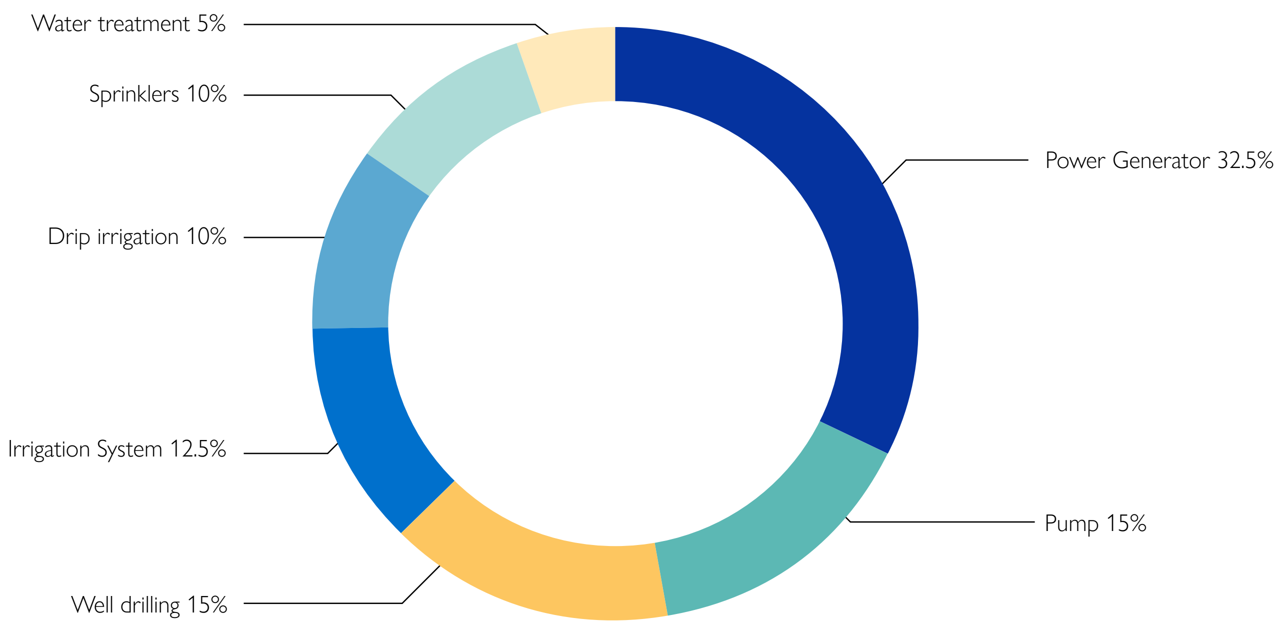

Figure 8 – Number of applications received per governorate

The survey shows that the requests related to small-scale irrigation infrastructure target mainly the following:

- A total of 32.5 per cent requested support to purchase a power generator system (PV solar system or diesel generators for farms not connected to the grid or suffering from power outages);
- A total of 32.5 per cent requested support for irrigation systems (drip irrigation 10%, sprinklers 10% and undetermined 12.5%);
- Fifteen per cent requested support for pumps;
- Fifteen per cent requested support for well drilling;
- Five per cent requested support for water treatment.

These figures were confirmed during the discussion with the farmers and various stakeholders.

Farmer requests were heavily concentrated on energy issues (cost and availablity). Since the daily number of hours of electricity supplyis very limited at the plots that are connected to the grid, and there is a need to have a diesel generator for the plots that are not connected to the grid (which increases the operation cost on the farmer), there is an opportunity to promote solar photovoltaic systems. The energy issue was confirmed in all governorates visited, including in the Kurdistan Region of Iraq (visited for a different study).

At the same level, farmers requested financial support for irrigation systems (drip irrigation for greenhouses, trees and vegetables, and central pivot systems for cereal crops, wheat and barley).

Pumps are needed in most of the irrigation systems and are requested for both surface water pumping or groundwater pumping.

Well drilling is needed in several areas, but requires a permit from the authorities. Well drilling is possible where salinity is low.

In the central and southerns area in Iraq, whose aquifers suffer from medium to high salinity, there is a need for water treatment solutions, which is not the case in the north.

Drainage is needed in the south, which is characterized by a flat alluvial plan, whereas it is not needed in the mountainous area in the north.

5. FEASIBILITY ASSESSMENT AND FINDINGS

Various solutions have been found for the problems identified above. This section identifies type of interventions that have considerable potential to contribute to create jobs, enhance productivity, and reduce food insecurity and poverty.

As informed by the Chambers of Commerce and Industries, it appeared that despite the existing capabilities of Iraqi industries, Iraq is still importing most of these irrigation systems and equipment.

5.1 MAIN FINDINGS

5.1.1 Energy costs

It is not suprising that solar powered pumping for irrigation is one of the biggest requests since the cost of fossil fuel-based technologies add substantial costs to irrigation. In addition such energy contributes to green house gases. Thus, photvoltaic solar technologies provide a solution to both the energy and climate concerns in agriculture.

Sustainable solar irrigation will have a significant impact on smallholder agriculture by improving irrigation systems and reducing operations and maintenance costs:

- First, it is a climate-smart solution that will enable access to smallholder irrigated agriculture;
- Second, solar irrigation will reduce fuel-based carbon emissions and energy costs;
- Energy costs are high. Not all farms are connected to the grid. In addition, the power supply in most of the areas is limited to 10 hours at most, which is creating additional burdens on farmers, who are then obliged to have an additional power supply system (diesel power generator) at an additional cost.

One concern with photovoltaic systems, however, is overexpolitation and grounwater depletion. Farmers will tend to consume more water if this water is provided for free and will use less water-saving solutions and irrigation techniques.

5.1.2 Farms and farm size

Potential farm size to be considered in potential interventions and support from EDF-a should be small (<30 dunum) to medium size (<30 to 200 dunum).

5.1.3 Salinity

Complaints about salinity were made in all the interviews conducted in the south, for both groundwater and surface water. Farmers indicated that salinity had been increasing.

Some farmers are treating their water to reduce salinity, but this obviously adds a cost that others cannot afford. Some farmers also had turbidity issues that can cause clogging issues for drip irrigation systems if filters are not used to address the issues.

5.1.4 Technology adoption

Nearly all the farmers and stakeholders interviewed were aware of water saving technologies they were not using. The main reason for not adopting new water-saving technologies was their cost.

5.2 POTENTIAL INTERVENTION WHERE EDF-A CAN PROVIDE FINANCIAL SUPPORT

The strategy used in the identification of components and key intervention areas is based on the main objective that IOM is trying to achieve, which is to support the irrigation water sector for local economic development in addition to job creation. Below is a list of various needed types of interventions based on the assessment conducted and discussions with stakeholders:

5.2.1 Well drilling and equipping

The availability of ground water resources and the quality of water in Iraq's aquifers are highly unequal. There are an estimated 88,000 wells across the country, but the figure is likely to be far higher due to illegally drilled wells.

This type of intervention requires an authorization from the General Commission for Groundwater at the MoWR. In some areas the authorization is granted within two weeks (Al-Zubair District – Al Basrah Governorate).

Grants could cover the following: Well drilling, developing, testing and installing a Variable Frequency Drive pump that can be operated using various power supply sources (electricity grid - diesel power generator- photovoltaic solar system).

5.2.2 Drip irrigation system

Drip irrigation is sometimes called trickle irrigation and involves dripping water onto the soil at very low rates (2–20 l/hour) from a system of small-diameter plastic pipes fitted with outlets called emitters or drippers. Water is applied close to plants so that only part of the soil in which the roots grow is wetted, unlike surface and sprinkler irrigation, which involves wetting the whole soil profile. With drip irrigation water, applications are more frequent than with other methods and this provides a very favourable high-moisture level in the soil, in which plants can flourish.

The grant will cover the following: supplying all items and materials of water pipes, fittings and pumps for farms and greenhouses.

The greenhouse irrigation market is growing at a significant rate. However, high investment to set up the system and its costly maintenance are the major factors hindering the growth of this market. In addition, depending on the type of crops, the greenhouse will require a cooling and/or a heating system.

Several challenges exist:

– The use of drip irrigation systems has increased in Iraq, which has led to the import of products that do not meet the standard specifications.[23]

– Emitters are sensitive to clogging.

– Iraq farmers are doing the design by themselves, which leads to irregular emitter discharge.

– As well, regular maintenance for the drip irrigation systems is needed at the end of growing seasons.

The equipment available at the suppliers' stores visited during the field phase shows that most of the pipes are imported either from Iran, Turkey or Jordan. The Jordanian equipment has a higher price and a better quality according to farmers and suppliers. Local industries provide these pipes but at a higher cost and farmers prefer the import-ed ones:

- Dripping: on the plots, it is possible to see in-line drippers of only one type but with variable spacing, mainly used for vegetable crops. These non-self-regulating drops have high flow rates that are not compatible with pipe diame-ters. As a result, the flow homogeneity along the ramp is degraded all along the small parcel overrun (pressure lost).
- The drippers have an adjustable flow by tightening a screw. This system, which seems interesting because of its adaptability, has little performance due to a lack of control over the flow rates on time and are very sensitive to clogging. Farmers mentioned that in some locations, the pipes cannot serve more than one year due to clogging.
- Jet diffuser: the equipment seen on the plots are adjustable and have the same discomforts as the adjustable drippers in terms of reliability of their flow settings and their sensitivity to clogging.

5.2.3 Subsurface Drip Irrigation

Subsurface drip irrigation is a variation from conventional surface drip irrigation techniques. By minimizing evaporation, it uses water more efficiently than surface irrigation. The depth that the laterals (also used in conventional drip irrigation) are buried at depends mostly on the tillage practices and the crop to be irrigated. It is a costly system that needs expert design and maintenance, but it is also a very effective method that transports the water directly to the roots and is especially appropriate for arid and windy locations. Before entering the distribution pipes, the water is filtered to minimize the risk of clogging. Still, the system must be designed so that all pipes can be flushed periodically.

5.2.4 Pivot / linear irrigation systems

Sprinkler irrigation is the method of applying water to crops in a way similar to that of rainfall. The water to be sprayed is distributed through a pipe system and then sprayed into the air through sprinklers so that the water breaks into tiny droplets when falling to the ground. This way, crops will get the desired amount of water required for their growth without wasting excess water.

The centre pivot system consists of one single sprayer or sprinkler pipeline of relatively large diameter, composed of high tensile galvanized light steel or aluminium pipes supported above ground by towers that move on wheels, long spans, steel trusses and/or cables. One end of the line is connected to a pivot mechanism at the centre of the command area; the entire line rotates around the pivot. The application rate of the water emitters varies from lower values near the pivot to higher ones towards the outer end by the use of small and large nozzles along the line.[24]

23 Al-Mehmdy (2020) Iraqi Journal of Agricultural Sciences (jcoagri,+16.pdf).

24 A. Phocaides (2000).Technical handbook on pressurized irrigation techniques – FAO.

The centre pivot is a low/medium pressure fully mechanized automated irrigation system of permanent assemble.

The cost of each system unit is relatively high and is therefore best suited to medium and large irrigated farms. Pivot systems can be supplied at a subsidized price from the State Company for Agricultural Supplies.

The wells feed the installation directly or after a booster downstream of the tank. The water network is made of buried pipe for central pivots. For other systems, pipes are also buried or left on the ground surface. The efficiency of the distribution is good.

Based on the site visits conducted in Iraq, it appeared that the plots equipped with solid sets have a good quality of distribution if equipped with adapted sprinklers and with the right spacing between devices. On the other hand, sprays used on pivot do not seem to be the most functional to reach a right distribution. Several maintenance defects have been identified, including non-vertical support rods, miscellaneous nozzles and spray mixtures on the same plot. These elements deteriorate the quality of water distribution with over-irrigated areas and other areas are under water stress. Crop homogeneity is poor and irrigation water is much less efficient on average.

Much less frequently, forage crops are irrigated with guns mounted on tripods. In some locations, subject to wind, this technique is not favourable. The spacing between sprinklers is more important, making the distortions of the water distribution potentially stronger on windy days.

Overall, spraying can have very good results when the installations are well studied and maintained with efficiency, so 85 per cent of the water is efficient. Otherwise, efficiency drops rapidly and can reach values close to surface irrigation.

Regarding pivots, and based on the site visits, the main finding is that for the systems connected to wells having high salinity, the upper tubes of the pivots were corroded. These tubes have the dual function of forming the structure of the machine but also of transporting the water to the sprinklers. To stop the internal corrosion of the galvanized steel tube, the farmers hooked a polyethylene pipe at about 2 meters off from the ground. The new nozzle plan, which must take into account the flow rate, pressure and length of the ramp, must be calculated with relevance. The results are not satisfactory for some farmers.

Pivots are very effective tools in terms of labour productivity. They also have a very good efficiency (90%) for water if well maintained (avoiding direct evaporation and wind drift). The changes imposed on farmers must be reviewed for some pivots As a result of corrosion, machines have structural disorders that need to be solved.

5.2.5 Water treatment solutions for salinity

Brackish water is any water sources with TDS between 1000 and 15 000 mg/L. Several systems exist for the treatment of brackish water:

- Brackish Water Reverse Osmosis System;
- Membrane Capacitive Deionization is an electrical process allowing the removal of ions from water;
- Water-smart treatment, which alters the behaviour of minerals in irrigation water.

Combinations and alternations of fresh water then brackish water is a feasible irrigation strategy tested in various countries (China’s Yellow River Delta for winter wheat, for example). This method allows a reduction in the needed flow, and the cost of the equipment needed is also reduced.

5.2.6 Photovoltaic irrigation-pumping systems

Water lifting practices and fossil fuel-based technologies contribute to green house gases, add substantial costs to water access, and have been associated with over extraction in many areas.

For these reasons, solar-powered water lifting and irrigation are spreading as a solution to both the energy and climate concerns in agriculture. Many perceive solar-powered irrigation as transformational because it expands smallholder agriculture production, increases household water security, and offers solutions for climate smart agriculture development. Solar irrigation will enable access to smallholder irrigated agriculture and strengthen productivity to achieve the Sustainable Development Goals on poverty and hunger.[25] One driver for solar irrigation is the reduction of fuel-based carbon emissions and energy costs,[26] as solar-powered pumps could replace diesel and petrol pumps, or electrical pumps on grids. A second driver for solar irrigation is that solar water lifting can be a cost–effective way to secure food production and sustain livelihoods, because solar pumps can be cheaper alternatives to petrol and diesel water lifting technologies.[27] Another driver for expanding solar water lifting is the decrease in production costs of photovoltaic equipment, which has contributed to affordability of the technology in recent years.[28]

5.2.7 Drainage and salinity management

Drainage is the removal of excess surface and subsurface water from the land to enhance crop growth, including the removal of dissolved salts from the soil. When rain or irrigation continues beyond what the soil can quickly absorb, it collects on the soil surface forming puddles. This excess standing water on the soil surface is called ponding water, and needs to be removed by overland flow to an open drain. Part of the water that can infiltrate the soil will be stored in the pores and used by the crop, and part of the water will be lost as deep percolation. When the percolating water reaches the part of the soil which is saturated with water, the watertable will rise. If the watertable reaches the root zone, the soil has become waterlogged, and the plants may suffer. This excess water needs to be removed as well with drainage.

In irrigated agriculture, drainage has an additional benefit – managing salinization.

Figure 10 – Salinization

25 Terlau, W., Hirsch, D., Blanke, M., 2018. Smallholder Farmers as a Backbone for the Implementation of the Sustainable Devel-opment Goals. Sustainable Development.

26 IRENA, 2016b. Solar Pumping for Irrigation: Improving Livelihoods and Sustainability. The International Renewable Energy Agency, Abu Dhabi.

27 Hartung, H., Plushke, L., 2018. The Benefits and Risks of Solar-Powered Irrigation – a global Overview. Food and Agriculture Organisation, Rome.

28 Kavlak, G., McNerney, J., Trancik, J.E., 2018. Evaluating the causes of cost reduction in photovoltaic modules. Energy Pol. 123, 700–710.

The main objective of drainage in agricultural land is to sustain land and water resources for agriculture.

Despite its importance, drainage often has a lower priority than other agricultural activities such as irrigation and on-farm management. Although the importance of drainage is widely acknowledged and there is increased awareness that there should be no irrigation without drainage, investments in drainage have lagged behind over the last decades.

A drainage system can be implemented through the use of perforated pipes, geotextile, and/or channels depending on the topography of the plot. The system should be designed in a way to connect by gravity the drains (pipes or channels) to the public drain outside the plot. Otherwise, a pump should be provided where it is not possible to connect by gravity (where the invert level of the downstream public drain is higher than the invert level of the upstream drain at the plot level)

5.2.8 Hydroponic projects

Introducing climate-smart agriculture techniques is needed in Iraq. A hydroponics pilot project requires no soil, very little water and, at the same time, allows income-generating activities that some farmers have never had before.

A hydroponics pilot project (one per governorate – at the Faculty of Agriculture) will help to incentivize conventional farmers and potential investors to change their current techniques and will serve as a model.

5.2.9 Digital agriculture / Irrigation technologies

Precision irrigation is defined as the application of a precise amount of water at the correct time and appropriate locations in an agricultural field.

As stated earlier, farmers' tendency is usually to overwater. Getting the amount of irrigation exactly right is a challenge for most.

Technology related to precision agriculture, can give farmers more information about what's going on in their fields. From detailed soil moisture readings to readily available data about sunlight, plant health and more, farmers now have the opportunity to leverage this data flow to better manage their operations, potentially leading to cost savings, water savings that could have a positive impact on the environment and marketing benefits as well.

The application of precision automated irrigation control system has been already positively tested at small scale level in Lebanon and could be replicated in numerous areas in Iraq. This innovative tool has a great potential to be scaled up thanks to capacity building and results sharing and dissemination.

It is recommended by this report to implement a pilot system at the Faculty of Agriculture and its impact will be monitored and measured in terms of a decrease in freshwater withdrawal, water and energy-saving, and productivity gains. The action will then enhance the adoption of these technologies and increase farmers' engagement.

Precision irrigation is projected to save approximately 10–15 per cent of water used in traditional irrigation. Other benefits include increased harvestable area, decreased incidence of diseases and leaching.

To improve the practices, it is first necessary to measure the initial situation. To date, the wells have no meters or flowmeters to measure the volumes used. Therefore, irrigators have no idea of the volumes produced. The meters would allow to follow the discharge flow to better follow the quantities brought by crop and devices.

In addition to the previous measurements, the checking of the performance of the well pumps by measuring the flow rates, pressure and ground water level, would help to avoid drifts and water losses in the riser.

Irrigators manage irrigation in frequency according to the seasons without first checking the reality of the needs. The analysis of practices and feedback would provide improvement plans. This monitoring could also alert people of water loss due to leaks.

The available systems can be more or less developped. Some of the proven technologies includes Artificial Intelligence and can improve the quantity and quality of agricultural output while using less inputs (such as water, energy, fertilizers, and pesticides), increasing efficiency by performing farming practices remotely and achieving positive environmental effects through lower input (fertilizer and pesticides) use.[29]

As precision agriculture technologies become easier to implement and more affordable, they could help raise income in smaller farms. In addition, they provides opportunities for more diverse and remunerative employment, especially for youth.

29 World Bank. 2019. Future of Food: Harnessing Digital Technologies to Improve Food System Outcomes. Washington, DC: World Bank Group.

Digital agriculture in Iraq is limited by many factors, including:[30]

- Low awareness and understanding of digital technologies and their potential agri-culture sector applications,
- Limited interest among public and private sector agents,
- Mismatch between the language used by technologies and those understood by farmers,
- Inadequate access to finance and data.

And this was confirmed through the EDFa call, since no financial support was requested for precision agriculture.

5.3 CASH FOR WORK

Potential activities identified for cash-for-work interventions can be provided at both the public irrigation and the farms using unskilled workers (Syrian refugees and internally dispalced persons).

- Cleaning of irrigation canals: This should be part of a regular maintenance schedule to keep irrigation canals free of weeds, reduce sedimentation, and prevent leaks;
- Rehabilitation of damaged irrigation infrastructure (such asdams, canals, diversion gates);
- Rehabilitation of irrigation equipment (such aspumps, generators, tanks and sprinkler/drip systems) replaced through enabled supply chains.

5.4 INFRASTRUCTURE

Iraq's infrastructure suffers from many problems at different levels (water storage systems such asdams and ponds), intake structure and canals. A study conducted by Othman I (2021)[31] using data from 2000–2010 shows that using water-saving irrigation techniques has insignificant impact on the total amount of irrigation water. The study shows that storage water structures have a much higher impact on irrigation water. The investments by donors and implementing partners in the sector should target not only the farmers but also larger infrastructure projects such as new irrigation schemes and rehabilitation of existing ones, including the development of small dams and rainwater harvesting ponds, irrigation canals, rehabilitation of intake structures and canals.

Targeting such projects would maximize community benefits. In addition, regular maintenance is necessary to keep this infrastructure working at full capacity. A maintenance plan should be developed by the MoWR, WUAs, farmers and communities.

5.5 AGRICULTURE INSURANCE PRODUCTS

Crop insurance is purchased by agricultural producers, including farmers, to protect against either the loss of their crops due to natural disasters, or the loss of revenue due to declines in the prices of agricultural commodities. In several African countries affected by climate change, agricultural markets have seen the introduction of crop insurance and ben-efited considerably. The introduction of such insurance builds resilience against erratic weather and also makes agriculture attractive to youth and women by making it a financial asset.

The report of the agricultural insurance portfolio for the Iraqi National Insurance Company[32] indicates the following:

- Almost complete reluctance to move towards agricultural insurance, due to the de-pendence of farmers on the government, which adopts the principle of compensation in-stead of agricultural insurance when natural disasters happen.
- In addition, agricultural insurance current mechanisms are found to be weak, with an absence of their own law that includes government support.

Agriculture grants and agricultural crop insurance are strategically important to boost smallholder farmers. For smallholder farmers, agriculture insurance offers risk reduction and peace of mind, which are needed to invest savings into businesses, and in particular in equipment and irrigation technologies that would potentially increase crop yields.

30 AUB – WorldBank group -2021 (Digital Revitalization of the Agri-food Sector in Mashreq- Focus on Iraq, Jordan, and Lebanon

31 Othman I (2021). Analyzing the Effectiveness of Modern Irrigation Methods in Iraq.

32 Majeed, Manal Hameed (2021). Analysis of the agricultural insurance portfolio for the Iraqi National Insurance Company.

6. VIABILITY OF INVESTMENTS IN SMALL IRRIGATION INFRASTRUCTURE

SMEs are considered essential for economic progress in most low- and middle-income countries countries.

Key informant interviews and EDF-a data show a strong demand exists among farmers for irrigation technologies, solar pumps and other agricultural water management tools and access to suitable financing is a primary barrier preventing smallholder farmers from investing in small-scale irrigation.

Because agriculture is one of the most important sectors in Iraq, focus on the upstream part of the value chain is needed, whether individual farmers or SMEs, as long as they are producing at a scale where they need capital and support services to grow.

EDF-a support is currently focusing on the farmers who may need financial support for the purchase of irrigation systems, greenhouses, pumps and power supply systems.

This support in small-scale irrigation is increasing the farmer's incomes and assets and providing employment for poor or marginalized communities in these farms. Such support will also lead to obtaining better-quality and better-priced produce, leading them to access high value markets.

Expansion of small-scale irrigation requires promoting more inclusive adoption of technologies for small-scale irrigation by addressing supply chain constraints, providing access to supporting services, and disseminating technologies that meet the needs of different farmers, through various partners such as WUAs.

Another impact of expanding small-scale irrigation will be that it ensures efficient use of resources such as water, energy and land and helps stakeholders adapt to or build resilience against climate change.

Several challenges exist and there are several obstacles that can be encountered during the course of operations. Poor management culture, corruption, regulation, lack of skilled workers and lack of reliable infrastructure are just some of the barriers encountered.

Moreover, additional challenges should also be taken into account in agricultural financial support, which is the influences of weather and perishability.

Without working capital and capital investment, farmers struggle with both day-to-day operations and implementing expansion plans. Crop planting and harvesting are time-sensitive and therefore, the availability and predictability of financing is essential for successful operations.

Private-sector actors can benefit from strengthened markets for irrigation equipment and irrigated produce, and various packages and plans can be developed in collaboration with the Chambers of Commerce. Examples can include lease-to-own and seasonal repayment plans. Various stakeholders in the country play important roles in overcoming these barriers, including private irrigation equipment suppliers through the Chambers of Industries and Commerce, farmer cooperatives, Ministry of Agriculture and in particular the State Company for Agricultural Supplies, MoWR and Water Users Associations that provide information, complementary inputs and incentives for farmers to adopt irrigation technologies, and NGOs that are providing financing services to smallholder farmers.

For these reasons, partnerships should be established:

- With the private sector: in order to implement cost-effective technology solutions that meet the needs of small farmers, especially in the field of small-scale irrigation and renewable energy. Private sector actors and chambers of industry and commerce should play a leading role, allowing for further integration, and commercialization of cutting-edge technology packages.
- With the public sector, especially with the State Company for Agricultural Supplies in order to provide support related to drip irrigation systems, center pivot irrigation and pumps.
- With the academic sector, universities, and colleges of agriculture in all governorates for technical assistance and training, in addition to creating job opportunities for graduates.

These interventions should be accompanied by measures at the county level, in particular the rehabilitation of the main irrigation infrastructure

7. IMPLEMENTATION AND MONITORING

Due to the specifities of the various types of interventionsa technical team (1 per governorate) is needed to support EDFa interventions.

The role of the technical team could be to:

- Assess the technical requirements, validate the project and collect data on the field for each project;
- Design systems;
- Support in implementation;
- Monitor the project at agreed-upon milestones;
- Introduce comprehensive on-farm water management programmes to educate farmers on precise irrigation requirements under the existing salinity and groundwater table depth conditions should also be given priority;
- Deliver on-the-job training and basic business-skill development to grow and sell.
- The technical team should include junior engineers from the faculty of Agriculture as well as professors, and should be equipped with portable equipment (multi-parameter kits for soil testing, water quality testing, flowmeters). This team can provide continuous training system for farmers and assistance, specifically on the following: Water requirements of crops

Farmers and staff managing irrigation need to understand and integrate the basics of plant water requirements to modulate the doses and frequency of irrigation. Through the sharing of real cases, the transmission of visual aids and the communication of updated values (for example, weather-dependent water demand), the quantities of water used could be reduced. Partnership with farmers associations or WUAs can provide these inputs and support.

KNOWLEDGE OF SOILS

The differences in the soil in the various areas have an impact on irrigation management, on water storage capacity and water lateral diffusion. These quantities will determine the volumes of soil mobilized and consequently the quantities and frequency of irrigation. For example, these data can be used to adjust characteristics or use of irrigation equipment, flow rate and density of dripping.

USE OF IRRIGATION EQUIPMENT

The use of irrigation techniques and equipment by farmers does not aim at saving water but satisfying what seems to them to be the water needs of the crops. Based on feedback about existing practices and material , significant margins of progress are possible: irrigation time, frequency, leaching, homogeneity of distribution, renewal of some equipment, performance control. This approach can be envisaged through auditing and group facilitation.

8. JOB CREATION POTENTIAL

The agriculture sector can be a catalyst for job creation and stability given the current economic challenges and social instability in Iraq. Agriculture is a labour-intensive sector and has a relatively strong long-term value-added elasticity of employment.

For every percentage point of growth in the value added of the agriculture sector, employment increased by 0.36 percentage points (while the corresponding employment increases for industry and service sectors were 0.30 and 0.20 percentage points, respectively).[33] In 2019, the agricultural labour force accounted for 18.1 per cent of total employment in Iraq.[34]

The World Bank estimates that the agri-food sector in Iraq has the potential to add over half a million jobs to the economy in the short run and about 2.5 million jobs over the medium term (5–10 years).[35] This potential can have significant effects, including for improved livelihoods and poverty reduction. Jobs are created in the production stage and also all along the value chain, including in processing, packaging and distribution, and related sectors such as services, transport and communication. Modernizing the agriculture sector requires developing new skills that can provide opportunities for more diverse and remunerative employment.

Moreover, Iraq had among the highest levels of internal displacement in the region and is hosting Syrian refugees. Agriculture can play a critical role in reducing poverty and vulner-ability by employing poor and marginalized population groups, including migrants, refu-gees and other displaced people. In Iraq, agriculture was found critical to the resettlement of internally displaced persons: 47 per cent of people returned to rural areas, where agriculture, farming and animal husbandry rank in the top three sources of income.[36] Evidence shows that more people have been returning to areas where agriculture, livestock and market activities around agriculture were resumed.

With the right investment and appropriate enforcement of social protections, agriculture can unlock progress toward social inclusion and reduce vulnerability. Therefore, enterprise development is fundamental to economic growth, job creation and human development. It can help the entrepreneur make ends meet, achieve financial security, accumulate wealth, become a leader and set an example for others; create jobs and incomes in his or her community; and catalyse a range of multiplier effects, from food security to improved nutrition.

The discussions with all the stakeholders showed that most of the equipment used for irrigation (even the one provided by the SCAS) are imported.

The proposed interventions listed in this report have potential to create jobs. These potential interventions can generate skilled and unskilled jobs at the farm level, but also at the supplier level, during installation, as well as through operations and maintenance. In addition, it will create jobs for consultants (fresh graduates engineers or faculty professors) in the design and supervision of these interventions.

- Temporary job creation: Skilled and unskilled daily workers will be needed for seasonal jobs. Seasonal jobs is considered to last 40 days.
- Permanent job creation: The number of permanent skilled workers is limited for most of the interventions, except for precision irrigation, where specialized technicians will be hired to implement the systems;
- Consultants: To design the photovoltaic systems, irrigation systems, wells and treatment systems, among others;
- Contractors: To implement the various systems;
- Suppliers for the various equipments.

Female labour force participation in agriculture exceeds female ownership of agricultural assets. In Iraq, women are more heavily employed in agriculture than men. Female empowerment is further undermined by women's limited ownership of productive assets.[37]

33 World Bank. 2018a. The Role of Food and Agriculture for Job Creation and Poverty Reduction in Jordan and Lebanon (English). Washington, DC: World Bank Group.

34 AUB – WorldBank group -2021 (Digital Revitalization of the Agri-food Sector in Mashreq- Focus on Iraq, Jordan, and Lebanon

35 World Bank. 2019i. "Iraq Economic Monitor, Fall 2019 : Turning the Corner - Sustaining Growth and Creating Opportunities for Iraq's Youth." World Bank, Washington, DC.

36 IOM (International Organization for Migration). 2019. IOM Integrated Location Assessment III

37 AUB – WorldBank group -2021 (Digital Revitalization of the Agri-food Sector in Mashreq- Focus on Iraq, Jordan, and Lebanon.

The analysis of EDF-a data shows the projected number of potential number of jobs created per type of intervention, indicating that well drilling and irrigation system enhancements could create an average of 5 to 15 jobs per onsite farm, of which 12.18 per centcould be for women.

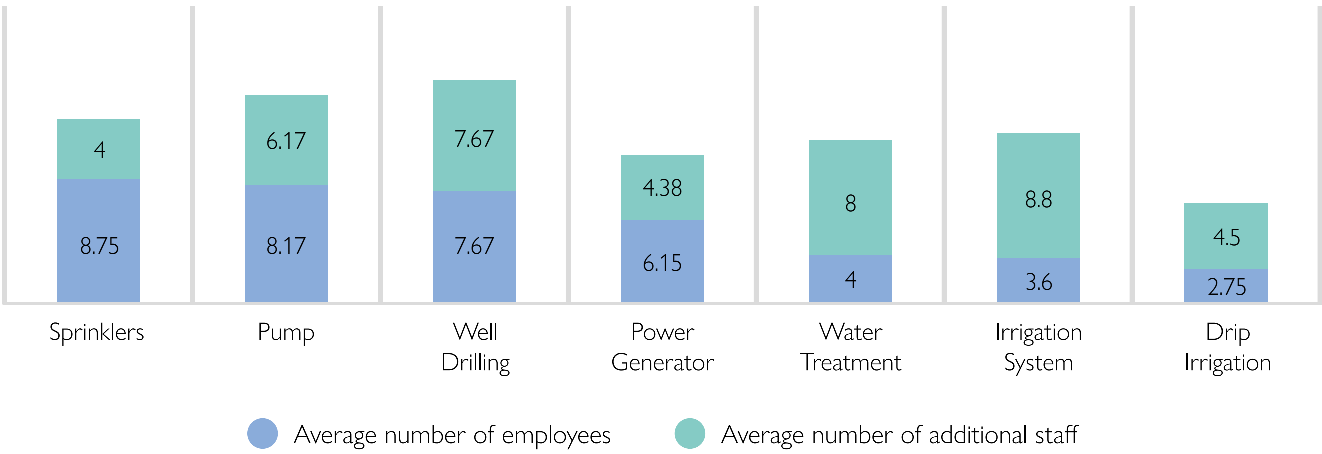

Figure 11 – Number of employees and additional staff expected per type of support accord-ing to applicant

Women's employment in agriculture tends to be both informal and seasonal. Drip and sprinkler irrigation systems will create jobs that exceeds 40 days of work, whereas pumps and power generators have a lesser impact on job creation.

9. CONCLUSION AND RECOMMENDATIONS

Iraq is facing water scarcity problem due to external and internal factors. External factors cannot be solved with short-term actions and will require concerted interregional efforts. The rehabilitation of Iraqi agriculture in the medium and long term can be achieved through a coherent and coordinated effort based on policy improvements and investment projects.

This study tried to conduct a bottom-up identification of priorities that can be used as a basis to formulate projects and interventions in small-scale irrigation development in Iraq. The aim is to introduce innovations in traditional irrigation systems, create improvements in on-farm water management practices and foster private-sector participation. It should be noted that localized interventions will have a low impact at a global scale but will solve immediate problems.

Nearly all the farmers and stakeholders interviewed were aware of water-saving technologies they were not using. The main reason for not adopting new water-saving technologies was their cost. Complaints about salinity were made in all the interviews in the south, for both groundwater and surface water. Farmers indicated that salinity had been increasing. Some farmers are treating their water to reduce salinity, but this obviously adds a cost that others cannot afford. Some farmers also had turbidity issues that can cause clogging issues for drip irrigation systems, and filters are not used to address the issues.

Energy costs are also high, and not all farms are connected to the grid. In addition, the power supply in most of the areas is limited to 10 hours at most. This is creating additional burdens on the farmers, who are obliged to have additional power supply systems (diesel power generators) at additional cost. Photovoltaic solar systems can significantly improve the irrigation system sustainability and reduce operations and maintenance costs.

Without working capital and capital investment, farmers struggle with both day-to-day operations and implementing expansion plans. Crop planting and harvesting are time-sensitive and therefore the availability and predictability of financing is essential for successful operations.

Private-sector actors can benefit from strengthened markets for irrigation equipment and irrigated produce, and various packages and plans can be developed in collaboration with the Chambers of Commerce. Examples can include lease-to-own, and seasonal repayment plans. Various stakeholders in the country play important roles in overcoming these barriers, including private irrigation equipment suppliers through the Chambers of Industries and Commerce, farmer cooperatives, the Ministry of Agriculture, the SCAS, the MoWR, and WUAs. The latter can provide information, complementary inputs and incentives for farmers to adopt irrigation technologies, while non-governmental organizations are providing financing services to smallholder farmers. For these reasons, partnerships should be established:

- With the private sector: to implement cost–effective technology solutions that meet the needs of small farmers, especially in the field of small-scale irrigation and renewable energy. Private–sector actors and chambers of industry and commerce should play a leading role, allowing for further integration and commercialization of cutting-edge technology packages.
- With the public sector, especially with the SCAS, to provide support related to drip irrigation systems, centre pivot irrigation and pumps.
- With the academic sector, universities, and colleges of agriculture in all governorates for technical assistance and training, in addition to creating job opportunities for graduates.

These interventions should be accompanied by measures at the county level, in particular the rehabilitation of the main irrigation infrastructure (rehabilitation of main irrigation canals to increase their operational capacity, and rehabilitation of the main drainage systems).

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