ICARDA

Science for resilient livelihoods in dry areas

RESEARCH COLLABORATION AGREEMENT

BETWEEN

INTERNATIONAL CENTER FOR AGRICULTURAL RESEARCH IN THE DRY AREAS

AND

DEPARTMENT OF AGRICULTURAL, FOOD AND FORESTRY SYSTEMS, UNIVERSITY OF FLORENCE

FOR CONDUCTING

RESEARCH PROJECT

AGROPASTORAL SYSTEM DIAGNOSIS: DESCRIPTION OF AGRICULTURAL PRODUCTION SYSTEMS AND RESTORATION INTERVENTIONS WITH A STRESS ON THEIR WEAKNESSES AND CONSTRAINTS

WITHIN

CGIAR RESEARCH PROGRAM ON INTEGRATED AGRICULTURAL PRODUCTION SYSTEMS FOR THE POOR AND VULNERABLE IN DRY AREAS (CRP 1.1)

December 2016

AUTHORS
Claudio Zucca, Enrico Bonaiuti [1], Francesco Garbati Pegna, Pietro Bartolini [2]

DISCLAIMER
The views expressed in this document do not necessarily reflect the views of the CGIAR System Organization.

REVISION HISTORY

Version	Date	Author(s)	Description
1.0	31 December 2016	Claudio Zucca, Francesco Garbati Pegna, Pietro Bartolini	Final document
1.1	15 April 2017	Francesco Garbati Pegna, Pietro Bartolini	Updating data Part 1 after field trip
1.2	15 November 2017	Francesco Garbati Pegna, Pietro Bartolini	Updating data Part 1 and Part 2 after field trip
2.0	05 May 2018	Claudio Zucca, Francesco Garbati Pegna, Pietro Bartolini	Revised document

[1] International Center for Agricultural Research in the Dry Areas (ICARDA), Jordan
[2] University of Florence, Department of agricultural, food and forestry systems (GESAAF), Italy

PART 1:

FARMING SYSTEM DIAGNOSIS: ANALYSIS OF THE OASES AGRICULTURAL SYSTEM IN MOROCCO, FOCUSING ON DATE PALM PRODUCTION

PART 2:

RANGELAND RESTORATION IN JORDAN

ANNEXES

PART 1
Annex 1. Farmers' interview form
Annex 2. Institutional interview form

PART 2
Annex 3. Dataset: interventions identified on public domain satellite images
Annex 4. Dataset: interventions reported by BRP-CAP until 2015
Annex 5. Dataset: JVA intervention database (several programs and implementing bodies) data provided by the Dam Department of the Water Authority of Jordan (2017)

PART 1:

FARMING SYSTEM DIAGNOSIS: ANALYSIS OF THE OASES AGRICULTURAL SYSTEM IN MOROCCO, FOCUSING ON DATE PALM PRODUCTION

Authors: Francesco Garbati Pegna, Pietro Bartolini [3]
Co-author: Claudio Zucca, Enrico Bonaiuti [4]

[3] University of Florence, Department of agricultural, food and forestry systems (GESAAF), Italy
[4] International Center for Agricultural Research in the Dry Areas (ICARDA), Jordan

1 FOREWORD

Saharan oases are nowadays threatened by the inadequacy of the traditional farming system unaltered for centuries. Overexploitation has caused soil and water degradation, while social changes have made dwellers life in oases unappealing and hard to be sustained. Modern technologies offer better chances for farmers in new settlements, expanding villages offer different job opportunities and adopting the urban lifestyle is now at reach for many. Moreover, climate changes affect the availability of water resources, scarcer and more erratic, and in many cases silting and desertification are the consequences of the degradation of natural plant barriers.

The oasis ecosystem requires a new approach where sustainability is achieved through the integration of economic, environmental and social dimensions (ANDZOA, 2017c) reviewed according to the historical changes that have occurred.

The oasis farming system is characterized by a certain complexity and should be approached holistically, however its pillar is, undeniably, the palm grove and its safeguard is indispensable for maintaining it alive.

2 OBJECTIVES

This work aims to contribute to the ongoing efforts to sustain the traditional oases structure in the western edges of the Sahara Desert. Oasis agro-ecosystem is an important heritage of the past and represents a sanctuary for traditional knowledge and biodiversity, but it needs human action to be properly maintained, assuring livelihood for its' dwellers. The difficulties of oasis agro-ecosystem to cope with modern agriculture have been described and analyzed since long time and various solutions have been proposed. Many initiatives have been undertaken along this path, involving different domains, either by public or private entities or by international organizations, and the results are sometimes encouraging. However, none of them took into account the possibility of enhancing the farming system through mechanization

This study discusses the possibility of introducing small mechanization in the oasis traditional farming system, an option neglected until now due to the usual linkage of mechanization to modern and large scale agriculture and to the bugbear of the initial investment. In this case, however, the proposed options based on small scale mechanization, notably motorized hand tools and light highly

mobile power equipment, could contribute to make agricultural work in the oasis system more attractive and sustainable.

With this aim in view, the study reviews some recent analyses conducted on this subject, singling out the most salient points, in order to outline the main problems that have been recorded, and verifies and integrates them with a field survey carried out in some of the most significant oases of Morocco.

A comprehensive diagnosis is summarized and possible interventions, based on introducing appropriate mechanization inputs, are suggested and discussed.

3 METHODOLOGY

This study has been conducted by collecting literature and field data on the historical and actual situation of the agro-pastoral system in the environment of Moroccan oases and by critically analyzing the collected information.

Data collection in the field was preceded by an in-depth literature research, by which we reviewed several reports from private and public agricultural programs launched in the Country in the past years, aiming at sustaining and developing the dwellers of the oases.

After this a field survey has been conducted, to collect direct observations and to interview stakeholders, in order to confirm or update the findings of the literature research and acquire original information. This survey targeted the public, private and international institutions working on Moroccan oasis systems, as well as single farmers or farmers' associations; all interviews have been complemented with direct observations of palm groves, processing and storage installations.

During the research phase, each component of the farming system was taken into account to maintain the approach as holistic as possible. During the following diagnosis and proposal phases, the work was focused on the date palm and, more specifically, on its cultivation and field operations.

4 INTRODUCTION

4.1 Geography of Morocco

Morocco is located in the northwest corner of Africa and is bordered by the Atlantic Ocean on the west and by the Mediterranean Sea on the north. The eastern border is with Algeria while the

southern one is with the Western Sahara, though *de facto* Morocco controls the western part of this region up to the Mauritanian border. Along the northern coast there are three Spanish enclaves: Ceuta, Melilla and Peñón de Vélez de la Gomera.

Morocco has four distinct geographic regions: a fertile coastal plain between the Mediterranean Sea and the Rif mountains in the north, the Atlas Mountains, extending across the country from southwest to northeast and into Algeria, a wide area of coastal plains lining the country's western seaboard, and the semiarid grasslands that merge with the Sahara Desert along the southeastern borders.

(Nations Encyclopedia 2018). The Atlas Mountains run down the backbone of the country, from the northeast to the south west and are divided into several sub-ranges: Middle Atlas, High Atlas and Anti-Atlas; they separate the mild coastline from the harsh Sahara. Most of the southeast portion of the country is in the Sahara Desert and as such is generally sparsely populated and unproductive economically since life is only possible within the sanctuary of the oases.

Among different major agro-ecological zones proposed for Morocco (Berkat & Tazi, 2004) on the basis of homogeneity in terms of landform/substrate-soil, rainfall and growing season (bioclimates and their thermal subdivisions), those of main interest for this study are:

- The Presaharan zone which is characterized by a very low (100 to 200 mm) and variable rainfall. Crops occupy only two percent of the land as they are mostly in valleys and oases. Most of the land is used for grazing sheep, goats, and some camels. Cropping is based on cereals, fallow, orchards (olive trees, date palms, fig trees, apple trees), forages and vegetables. Two irrigated perimeters are in this zone: the Ouarzazate perimeter and the Tafilalet perimeter. In the Presaharan Zone lithosols and regosols dominate, in association with sierozems and regs. In the valleys, saline soils are frequent;
- The Saharan zone which is characterized by a very low (less than 100 mm) and erratic rainfall. Thus, cropping is limited to irrigated areas, or areas receiving runoff. Main crops are cereals, forages and vegetables. However, the most important activity is extensive livestock production (goats, sheep, camels). Soils are mostly yermosols, associated with sierozems, lithosols and saline soils.

Fig. 1: Physical Map of Morocco (The View from Morocco, 2018)

From an administrative point of view, the kingdom of Morocco is divided in 12 regions, subdivided in prefectures and provinces, respectively for urban and rural areas. Prefectures are divided in *arrondisments*, and provinces in districts, each one containing several municipalities both urban and rural. In 2010 the country started a process of decentralization, granting more power and greater autonomy to regional and local authorities, especially in the disputed area of Western Sahara (comprehending part of Guelmim-Oued Noun region, and the entire surface of Laâyoune-Sakia El Hamra and Dakhla-Oued Ed Dahab regions).

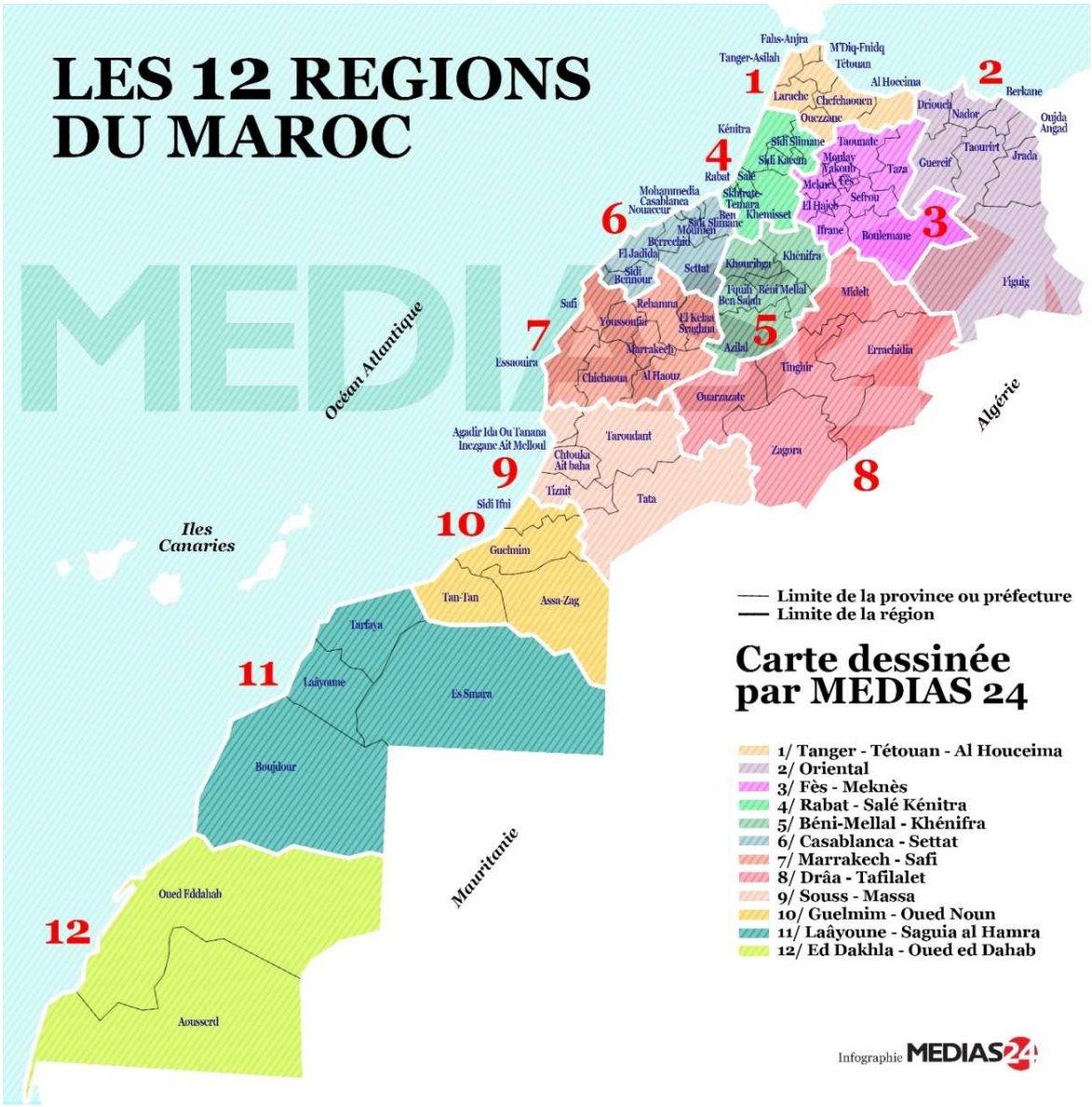

Fig. 2: Political map of Morocco (Medias24, 2018)

Morocco has a good agricultural potential due to the climate and to the several fertile areas in the coastal planes or stretched along the mountain valleys. Some less productive forms of agriculture also exist in the south-eastern areas in the oases scattered along the major water sources. Agriculture represents the 14-25% of GDP, depending on climatic variations (Toumi, 2008) and accounts for 80% of the work in rural areas; the rural population represents the majority of the Country's population.

4.2 Moroccan oases

An oasis is an isolated area in a desert region made fertile by the existence of a water source which allows vegetation to grow. They vary in size from just a few palms and shrubs to wide areas, often stretched along permanent or temporary water courses, where villages and even cities can rise and prosper. Larger oases can hence provide habitat for animals and humans which can practice agriculture by means of irrigation, by building dams or digging wells and constructing channels, in some cases even complex systems of galleries to convey water from distant sources (e.g. *khettara*, *foggara*, *guettara*, etc.). The most common vegetables are trees such as date palms, olives, figs and citrus, and herbaceous plants such as wheat, barley, millet, maize, Alfalfa and vegetables that coexist synergistically in the so called three layer cultivation.

There are different types of oasis. From a geographical point of view, we can distinguish between new oasis in North America and Australia, and old oasis developed along the caravan trade routes in the arid region of Africa and Asia (Novaterra, 2009).

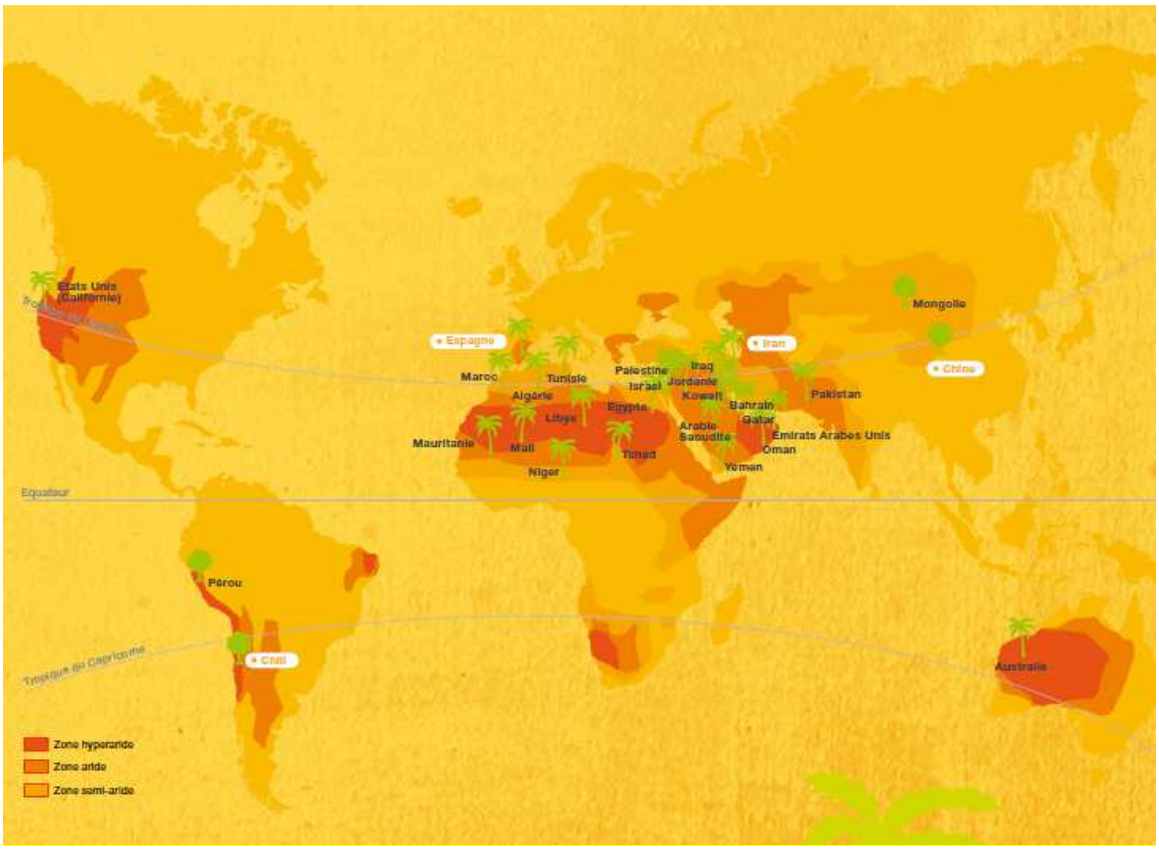

Fig. 3: Location of main oasis areas in the world (Novaterra, 2009)

A general classification can be based on the water sources which characterize three main types of traditional oasis: river, groundwater and spring oases, although sometimes the characterization is not so clear and different water-gaining techniques are used in combination.

- River oases are located along perennial or semi-perennial rivers. The surface water is directly used for irrigation in fields, usually located on fertile sediments. The relative abundance of water, and the fine sediment brought by occurring floods maintain soil fertility, granting a good productivity. Traditional irrigation system consists of several small dams which channel surface water into a complex irrigation channel network, where water is lead simply by gravity. Plots are irrigated by flooding.
- Groundwater oases are typically insular, located where groundwater is close enough to the surface to be tapped. The extraction of groundwater (using animal traction or digging underground tunnels) requires a high degree of organization at local level and a high labor cost. Groundwater oases are usually smaller than river oases, with a less intensive agriculture, and more subject to water table changes.
- Spring oases are insular type oases located in proximity of small springs. The spring usually has a limited flow, very variable during the year and subject to drought. Water collection is easier than groundwater oases and less labor intensive (De Haas, 2001).

The oasis heritage plays an important ecological role in maintaining biodiversity. Unfortunately, nowadays this heritage is severely deteriorated by several factors, including the irrational exploitation of water resources, desertification and climate changes. The degradation of oasis areas involves the abandonment of many date palm orchards and the exodus of the population to urban centers, which further accelerates the deterioration of oasis ecosystems (FAO, 2017b).

Moroccan oases host more than 5 million inhabitants (15,5% of Moroccan population), are spread over 5 regions and 16 provinces and constitute the most important barrier against desert advancing. Here local farmers have established and maintained for a long time effective and sustainable water management practices and crop growing technologies to combat water scarcity condition.

The majority of Moroccan oases are located between the eastern slopes of the Atlas Mountains and the Algerian border, at a latitude broadly included between 32°and 28° N. The most important areas are those along the Ziz, Gheris, Todra and Draa oueds. River oases are concentrated at the southern and eastern foot of the Atlas chain, an area that suffers less aridity, thanks to mountain rainwater and where many rivers drain into the desert. The most important are the Drâa and Tafilalt-

Ziz basins, other important water curses are the Todra and Gheris. Spring oases can be found in the Bani Region. The 8 Moroccan provinces where oases are present are Figuig, Ouarzazade, Tinghir, Midelt, Tata, Zagora, Errachidia and Assa Zag; a list of the single municipalities is given by ANDZOA (ANDZOA, 2017).

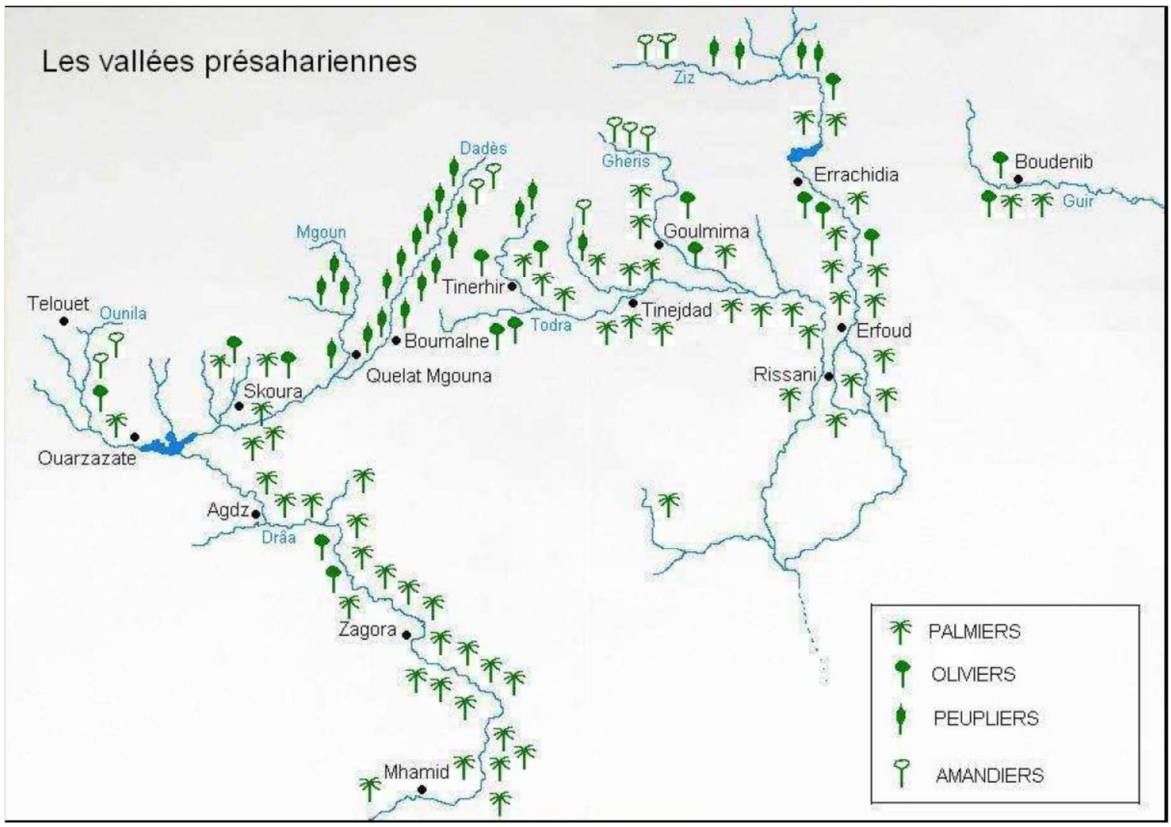

Fig. 4: Locations of the main river oasis in Morocco (unknown source)

From an administrative point of view the traditional oasis area includes both urban and rural municipalities. Rural municipalities include several *ksour* (singular: *ksar*), that can be considered the smallest administrative unit in the area. A *ksar* is a community/village that takes its name from the typical fortified building spread all over the region. A *ksar* is often ruled by customary law, especially in Berber communities, including the land and water management. There are four types of land in the *ksar*:

- *Melk* land: it represents the majority of the *ksar* land. It is divided in small private plots, usually smaller than 5 ha each. These plots are cultivated with a mix of annual and tree crops. The irrigation is usually provided by traditional system like *khettara*, or by modern pumping station.
- *Bour* land: it is collective land, usually used as common grazing land, cultivated only in occasion of high rainfalls.

- *Habous* land: land donated to the local mosque, due to lack of living heirs or by last will. Its management is responsibility of the local imam, or in general of the Ministry of *Habous* and Islamic Affairs.
- State-owned land: it represents a portion of land owned directly by the state, usually not cultivated.

According to Islamic tradition, each single plot is owned by the head of the family and after his death, the land is distributed in different proportion among all closest relatives: usually a daughter receives only the half of the land received by her brother. This natural plot fragmentation was further increased thanks to marriages between different *ksour* (Fratucello, 2015).

Moroccan oasis are also inscribed in the UNESCO World Heritage list and moreover the provinces of Ouarzazade, Errachidia and Zagora have been recognized by UNESCO as the "Oasis Du Sud Marocain Biosphere Reserve" (ANDZOA, 2017a,b), where one of the 3 fundamental functions is "fostering economic and human development that is environmentally and socially sustainable and culturally appropriate" (UNESCO, 2017).

5 Literature review: support initiatives to the oasis system in Morocco

In witness of the importance that is attributed to the oasis system there are many national agencies and policies, international organizations and NGOs supporting agriculture in the Presaharan and Saharan areas of Morocco.

5.1 FAO

FAO has stated among its priorities for deploying its activities in Morocco the sustainable management of natural resources and the improvement of livelihood in rural areas within a framework of adaptation to climate changes (Priority domain 2).

In 2002 FAO launched the Globally Important Agricultural Heritage Systems (GIAHS) program, in order to safeguard and support specific agricultural systems and landscapes traditionally created, shaped and maintained by generations of farmers and herders, using locally adapted management practices. GIAHS includes a Moroccan site, the oasis system of Imilchil-Amellago site in the Atlas Mountains.

At COP 22 FAO supported the Ministry of Agriculture and Maritime Fisheries in launching the Sustainable Oasis Initiative and expressed its willingness to support its implementation.

Recently FAO in collaboration with Moroccan institutions, has formulated a project aiming at the "Revitalization of oasis agroecosystems through a sustainable, integrated landscape approach in the Draâ-Tafilalet Region" (OASIL Project). This project will be implemented during the period 2017-2021 (FAO, 2017a).

Table 1: FAO project description (FAO, 2017a,b)

Project title	**Description**
GIAHS	GIAHS program safeguards the of Imilchil-Amellago oasis system in Eastern High Atlas since 2011, recognized an ingenious system of the world agricultural heritage for its exceptional biodiversity. However, in order to fight the progressive degradation of the oasis area, FAO, in collaboration with Ministry of Environment, the Ministry of Agriculture, *Agence Nationale pour le Développement des Zones Oasiennes et de l'Arganier* (ANDZOA), ADPS, the *Institut National de la Recherche Agronomique* (INRA) and Global Environment Facility (GEF), identified four other potential sites: Ait Mansour, Akka, Assa and Figuig.
OASIL	OASIL project is an initiative promoted by FAO in collaboration with Ministry of Environment, *Agence Nationale pour le Développement des Zones Oasiennes et de l'Arganier* (ANDZOA) and Global Environment Facility (GEF). The project will be operative in the period 2017-2021. Its objective is to revitalize oasis agroecosystems in the Draâ-Tafilalet region to achieve productivity, attractiveness and health, and to sustain and make more resilient the livelihoods of the local communities. OASIL supports the dissemination of knowledge on oases, strengthens political dialogue and facilitates the adoption of strategies and plans for sustainable oasis management at both national and regional levels. OASIL encourages the use of an integrated approach for the management of oasis agro-ecosystem, with a deeply involvement of all stakeholders in the decision process.

5.2 National agencies & policies

In the last decade various agencies have been constituted with the aim of supporting the development of the Presaharan and Saharan areas of Morocco (see par. 6.1.3) along with national policies and programs. The most relevant ones for this study are the *Agence Nationale pour le Développement des Zones Oasiennes et de l'Arganier* (ANDZOA) and the *Agence pour la Promotion et le Développement Economique et Social des Provinces du Sud du Royaume* (ADPS), the *Direction de l'Aménagement du Territoire* (DAT), the *Plan Maroc Vert* (PMV) and the *Programme d'Appui Budgétaire à la Politique Sectorielle Agricole* (PAPSA).

5.2.1 *Agence Nationale pour le Développement des Zones Oasiennes et de l'Arganier*

The *Agence Nationale pour le Développement des Zones Oasiennes et de l'Arganier* (ANDZOA) is a governmental institution created in 2009/2010, as part of the Ministry of Agriculture, Fisheries, Rural Development and Forests. ANDZOA has no operative role in the field, its role is supportive, working and cooperating with all the institutions and organizations involved.

ANDZOA main objectives are:

- Improvement of socio-economic indicators and infrastructures in the region;
- Increasing regional incomes, in order to support the demographic increment, focusing on the regional resources like agriculture, tourism, mining industries and handicraft;
- Fundraising and international partnerships creation;
- Supporting development programs.

ANDZOA works on four agricultural production chains:

- Date;
- Argan;
- Perfume rose;
- Saffron.

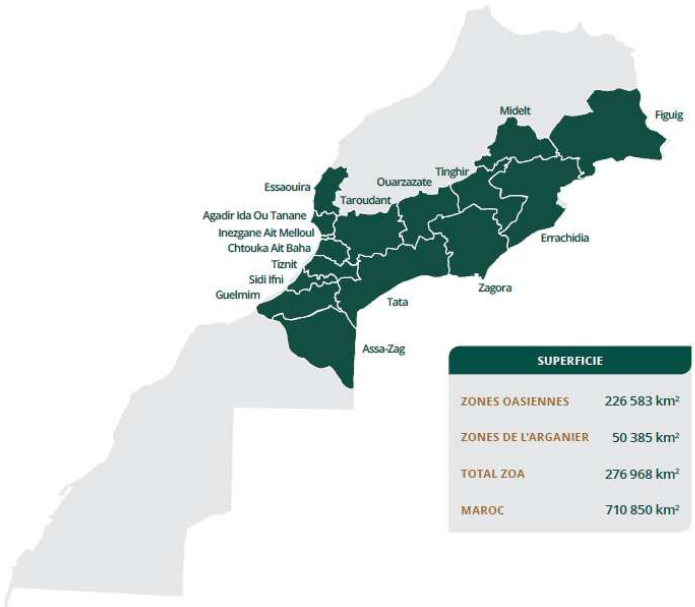

Figure 5: Operational area of ANDZOA (ANDZOA, 2017)

ANDZOA is responsible of the Sustainable Oasis Initiative, launched during the COP22 of Marrakesh in 2016, aiming to a better recognition of the unique character and the vulnerability of oases and the implementation of actions to protect the oasis heritage, in particular, its biodiversity and its human system, and the valuation of oases' economic potentialities for sustainable development (ANDZOA, 2017c). The objective of the program is to mobilize national and international resources to protect and restore the traditional oasis ecosystem, endangered by desertification.

5.2.2 *Agence pour la promotion et le développement économique et social des provinces du Sud du Royaume*

The *Agence pour la promotion et le développement économique et social des provinces du Sud du Royaume* (ADPS) is a public institution in charge of development strategies and action plans in the southern regions of Morocco. The target area comprehends three regions : Guelmim-Oued Noun, Laâyoune-Sakia El Hamra and Dakhla-Oued Ed-Dahab, including the entire surface of the disputed Western Sahara.

ADPS works as a connection between different ministries and research institution in order to coordinate their efforts to produce concrete economic and social impact.

The *Programme Oasis Sud* (POS) was a program launched by ADPS between 2006 and 2015 in collaboration with PNUD. POS has the following objectives:

- Supporting sustainable regional development;
- Local products promotion;
- Local heritage valorization;
- Environment protection.

5.2.3 *Direction de l'Aménagement du Territoire*

The *Direction de l'Aménagement du Territoire* (DAT) is a branch of Ministry of Urbanism, National Land Settlement, Housing & Policy of the City, in charge of development strategies and action plans. Lacking a specific agency for the Draâ-Tafilalet region, the DAT is in charge of the *Programme de Développement Territorial Durable des Oasis du Tafilalet* (POT).

POT was a program implemented between 2006 and 2015 by the Ministry of Energy, Mines, Water and Environment management. POT has the same general objectives of POS, but implemented in Draâ-Tafilalet region (Royame du Maroc 2010).

5.2.4 *Plan Maroc Vert*

The *Plan Maroc Vert* (PMV) was launched in 2008 by the Ministry of Agriculture, Fisheries, Rural Development and Forests. PMV aims at reinforcing the role of agriculture in the GNP composition and fighting against poverty through the creation of new jobs and the and improvement of agricultural incomes for rural inhabitants by sustaining investments, exports and aggregation between the production and the commercial and industrial phases (Ministere de l'Agriculture, de la Pêches Maritimes, du Développement Rural et des Eaux et Forêts, 2018b).

5.2.5 *Programme d'Appui Budgétaire à la Politique Sectorielle Agricole*

The *Programme d'Appui Budgétaire à la Politique Sectorielle Agricole* (PAPSA), was funded by EU starting from 2010. PAPSA general objective is to support PMV by dynamizing and reinforcing agricultural performances, in terms of competitiveness and environment conservation, and contribute to national food security. More specifically the program aims to invigorate the smallholder related food chains in the less favorable areas of the Country, by promoting the improvement of the productive basis and the sustainable use of natural resources, especially water.

PAPSA intervenes mainly in the areas located east of the Atlas Mountains (Drâa, Oriental, Boulemane and Tafilalet) which are the most disadvantaged of the Country according to the classification of the *Haut Commissariat au Plan* (*Carte de pauvreté* 2007), due to scarce precipitations, shallowness of soils and susceptibility to desertification. The supported chains are those of sheep meet, of date palm, of olive trees and of other products of the territory. (European Commission (EC), 2013).

5.3 International cooperation

Several international cooperation agencies work in Morocco on many different development projects. The most important ones, involved in date palm-related projects in the area are the German Corporation for International Cooperation GmbH, the Belgian Development Agency, the U.S. Agency for International Development and the Millennium Challenge Corporation

5.3.1 German Corporation for International Cooperation GmbH

The German Corporation for International Cooperation GmbH (GIZ) has been working in Morocco on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ) since 1975. Nowadays GIZ is taking on several commissions in Morocco for different clients, such as

the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB), the Federal Foreign Office (AA), the Federal Ministry for Economic Affairs and Energy (BMWi), the European Union, and Moroccan companies. GIZ has about 130 staff in Morocco and an office in Rabat since 1999.

GIZ main interest topics are:

- Sustainable economic development;
- Conservation and management of water resources;
- Renewable energies and energy efficiency;
- Environment and climate change;
- Good governance;
- Health.

Actually, GIZ carries on two projects directly or indirectly related to oasis development: "Promoting employment through renewable energy and energy efficiency in the MENA region" (RE-ACTIVATE) and "Economic and rural development in disadvantaged regions of Morocco" (PEDEL), as reported in table 2.

Table 2: GIZ project description

Project title	**Description**
RE-ACTIVATE	The objective of the project is to increase the use of renewable energy in Morocco, Tunisia and Egypt, reducing environmental pollution and producing new jobs. It is related indirectly with dates production. In Morocco, the project works in cooperation with ORMVA, to provide energy to irrigate a date plantation in Tamassint (Errachidia). The plantation covers 260 ha provided by the state. It will be divided in 54 smaller plots with modern management, assigned to the young member of the *Association Tamassint des Usagers des Eaux agricoles* (ATUEA). GIZ plans to install solar pumps to serve the 12 wells present in the plantation and had already produced a preliminary study: *Etude technico-économique pour des installations de pompage solaire dans le cadre de l'extension des superficies des palmeraies pour l'exploitation du palmier dattier à Tamassint (Province d'Errachidia, Maroc)*.
PEDEL	The objective is to improve the economic performance capacity and employment situation of local actors, including smallholders and farmers' associations. Sales and profitability are on the increase and new markets are being developed. The project works with local stakeholders, in order to identify sectors where there is potential for growth and employment. Local stakeholders are enabled to identify and exploit existing economic opportunities with the support of the project (technical/management training). The initial

	focus of the project are the rural regions in southern Morocco, the same target of the Plan Maroc Vert and date production is identified as a potential growing sector: Midelt, Ouarzazate, Tata, Tinghir and Zagora provinces.

5.3.2 Belgian Development Agency

The Belgian Development Agency (ENABEL), formerly known as *Cooperation technique Belge* (CTB), was created in 1998 and recently reformed in January 2018. It implements Belgium's international development policy. Under the 2030 Agenda for Sustainable Development, ENABEL carries out public service assignments in Belgium and abroad.

In Morocco ENABEL carries on several projects on capacity development, water management and the improvement of local value chains. Two projects are related to date palm: *Appui et accompagnement des groupements d'intérêt économique pour le développement de la filière phoenicole au niveau des oasis marocaines* (PAGIE) and *Développement des filières du safran et du palmier dattier dans les régions Souss-Massa et Drâa-Tafilalet* (PDFSD), as repored in table 3.

Table 3: ENABEL project description (ENABEL 2018)

Project title	**Description**
PAGIE	The objective of the project is the development of date production chain strengthening farmers and other stakeholders, especially the GIEs. The project also contributes to improve the economic conditions of small farmers, increasing date value and improving their ability to deal with market, in accordance to the second pillar of *Plan Maroc Vert*. The project includes training and technical support as main activities.
PDFSD	The objectives of the project are to increase saffron production, rehabilitate old palm groves and improve the value chain of both products. The project contributes to the second pillar of *Plan Maroc Vert* supporting family agriculture with training and technical support to farmers and other stakeholders.

5.3.3 U.S. Agency for International Development

The U.S. Agency for International Development (USAID) is an independent agency of the U.S. Federal government. USAID is responsible for managing foreign aid policies and assistance programs, and it is one of the biggest aid agencies in the world. It works on five priorities:

- Disaster relief;
- Poverty relief;
- Technical cooperation on global issues, including the environment;

- U.S. bilateral interests;
- Socioeconomic development.

The collaboration between the U.S. and the kingdom of Morocco was established in 1957, with the objective to cooperate and to make real and substantial improvements in the lives of Moroccan citizens. Nowadays, USAID is involved in several projects in the country, on many different topics, including water management and agricultural growth.

5.3.4 Millennium Challenge Corporation

The Millennium Challenge Corporation (MCC) is a bilateral U.S. foreign aid agency established in 2004. Although sharing the overall objectives with USAID, MCC is an autonomous agency, that was created on rigorous principles of transparency:

- Competitive selection: to be eligible of assistance, a country needs to pass an extensive performance evaluation by MCC's board;
- Country-led solution: each country must identify the priorities for achieving sustainable economic growth and poverty reduction. The projects are defined in close partnership with MCC;
- Country-led implementation: after signing an agreement compact, each country set up the Millennium Challenge Account (MCA), an accountable entity to manage and oversee all aspects of the implementation of the project compact.

Morocco signed the compact agreement in 2006 and in 2008 the management entity, the Agency of Partnership for Progress (APP), was created. The Morocco Compact is made up of five Projects: Fruit Tree Productivity, Small-scale Fisheries, Artisan and Fez Medina, Enterprise Support, and Financial Services. Only the first one is of interest for this study, being related to date production, as described in Table 4.

Table 4: MCC project description (APP, 201?; MCC, 2018)

Project title	**Description**
Morocco Fruit Tree Productivity Project	The project contributes to the second pillar of *Plan Maroc Vert*. It aims to stimulate growth in the agricultural sector through transformation from extensive annual crops, like cereals, to more productive market-oriented cultivation of perennial tree crops (olives, almonds, figs, dates) based on sustainable management of soil and water resources and improved links to national and international markets. The project main elements are: - Rain-fed Olive, Almond and Fig Tree Intensification and Expansion Activity;

	- Olive Tree Irrigation and Intensification Activity; - Date Tree Irrigation and Intensification Activity; - Fruit Tree Sector Services; - Catalyst Fund. The last three points are most relevant to this study: the project supports the intensification/rehabilitation of existing date palm cultivation, providing technical assistance to producers, cooperatives and associations. Aiming at rehabilitating approximately 220,000 existing date trees (including pruning, cleaning and fertilizing), APP has addressed quality and quantity constraints through efforts aiming at improving irrigation infrastructure, water management practices, production and post-harvesting practices, expanding date palm plantations, providing technical assistance in farmer cooperative development and capacity building, and linkages to higher-end markets. It also offers value chain support services in form of training, applied research, support to the development of market information for agribusinesses, and pilot project to promote a greater integration of women in the value chain. There are 12 date palm plantations included in the Fruit Tree Productivity project (about 15,000 Ha), located mainly in the Draâ (2 plantations), Tafilalet (5), Figuig (1) and Tata (4) regions. The general idea was to attract private investment, in order to self-sustain the agricultural intensification. Unfortunately, the project failed in attracting private investor, and apparently it was reshaped in order to provide funds to ORMVA, that use them inside *Plan Maroc Vert* to build a series of cold storage units in service of small producers.

Although the claim to be transparent and more accountable than other aid agencies, obtaining detailed information about MCC activities resulted very difficult, especially considering that contacting APP proved to be impossible.

6 MOROCCAN OASIS AGRICULTURAL PRODUCTION SYSTEM

6.1 Oases structure and characteristics

An oasis is characterized by an intensive cultivated area, usually with a three-layer structure, located in a desert or arid environment. The oasis ecosystem is mainly based on the palm grove: date palms form the upper layer of the oasis structure, granting shade for fruit trees (figs, almonds, olives, and pomegranates) and other crops (barley, wheat, sorghum, alfalfa and several vegetables) on the lower layers, and contributing to the microclimate. A well-managed palm grove is vital for the maintenance of the traditional oasis organization.

Oases are highly artificial and sensible ecosystems, which enable sustainable agriculture under arid climatic conditions. Oases are characterized by a high degree of collective soil and water management. The collective maintenance of irrigation systems is labor intensive, and generally requires a high degree of central political organization at the community level.

Even if artificial, the oasis ecosystem, based on traditional knowledge, has proved to be sustainable and highly productive.

Oasis systems have also a strong connection with animal husbandry, historically represented by trade relationship between sedentary and nomadic people. Animals grant high value nourishment, labor force for transport, water extraction and ploughing, and also manure to increase soil fertility. In exchange the oasis produces fodder to feed the animals.

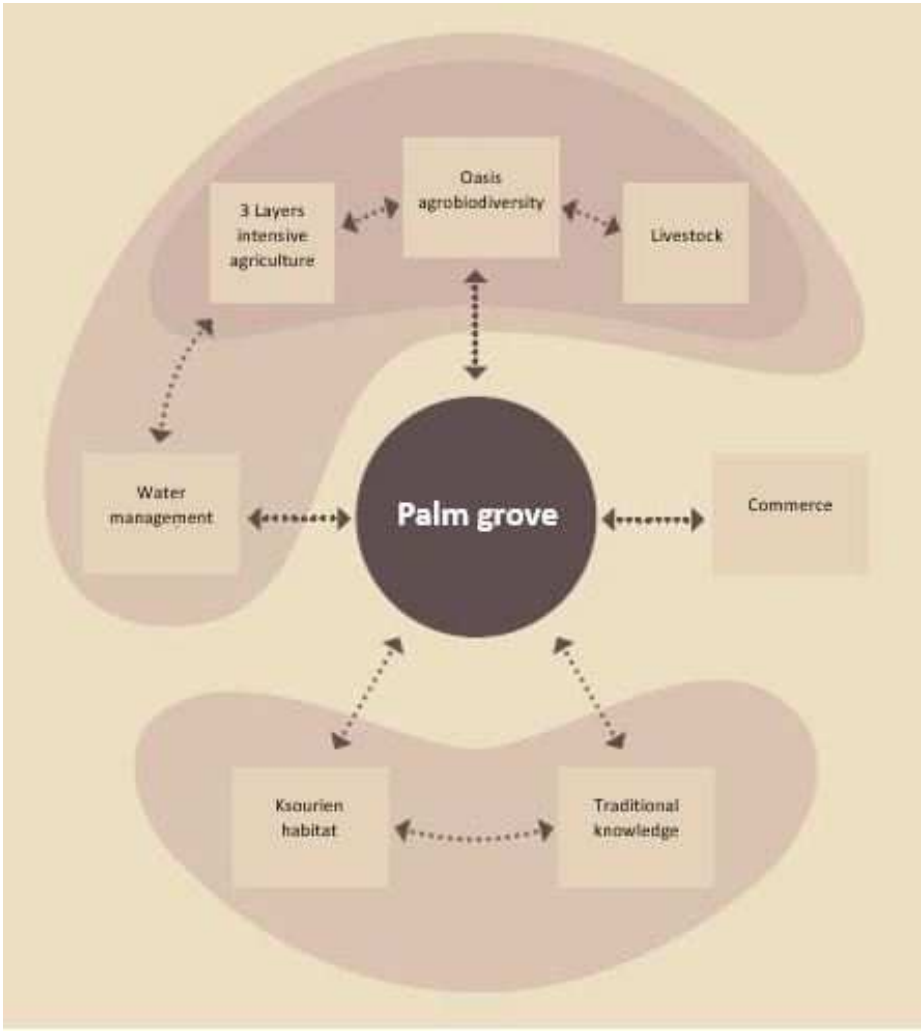

Fig. 6: Traditional oasis organization (*Agence pour la Promotion et le Développement Economique et Social des Provinces du Sud du Royaume*, 2015)

Nowadays, due to socio-economic and political changes traditional oasis agriculture is in serious danger. The collapse of ancient caravan trade, the abandoning of nomadism and political and economic integration in the Moroccan state resulted in the economic marginalization of oasis agriculture. The opening up of arid regions and increased mobility have provoked mass emigration to the urban areas and to Europe. Actually, migrants' remittances constitute the most important revenue for the oases, while agriculture only provides supplementary revenue and is often subject of strong aversion (De Haas 1998).

In this condition, land use in the oases has become more extensive, in some cases fields are even entirely abandoned, and traditional common law is hardly enforced. The progressive degradation of the palm grove undermines the collective soil and water conservation measures, provoking the collapse of the agricultural infrastructure, especially the vital irrigation systems.

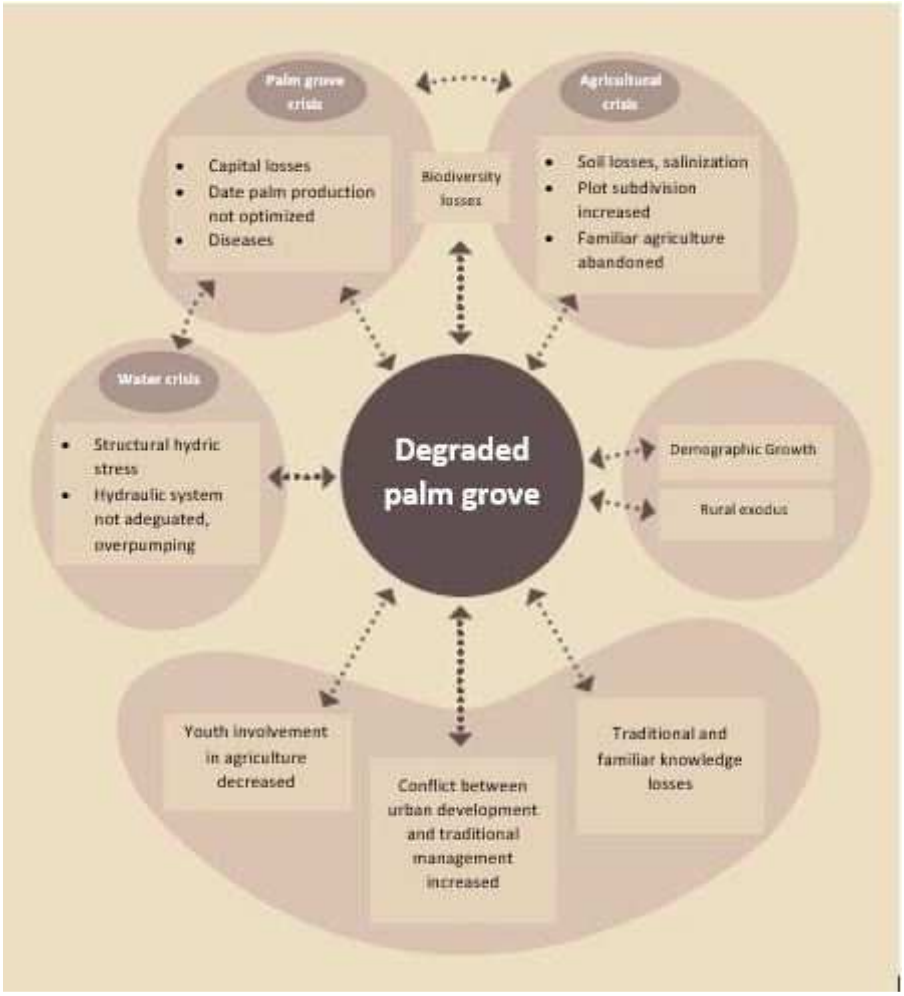

Fig. 7: Degraded oasis organization (*Agence pour la Promotion et le Développement Economique et Social des Provinces du Sud du Royaume*, 2015)

6.2 Main issues in Moroccan oasis system

The evident inadequacy and obsolescence of the oasis system has brought to a deep crisis that is leading to its' total collapse. Much has been done to analyze and identify the causes of this crisis and analysts largely agree on the most evident ones.

A report of ICARDA (Dahan et al., 2012) provides some useful information for understanding the constraints of the Moroccan agricultural sector. Rural areas of Morocco are characterized by poor socioeconomic infrastructure, low levels of education, inadequate support services and an ageing farm population. Farmers are therefore not equipped to face the challenges of an economy that is opening up to free market competition.

The major causes of insufficient productivity in the agricultural sector are:

- Degradation of natural resources;
- Rural poverty;
- Insufficient social infrastructure;
- Limited involvement of the rural population, especially women, in the development process;
- Poor use of the Government's human and financial resources;
- Virtual absence of rural financial services for small farmers and the rural poor.

The report focuses mainly on land degradation stating it is not just a consequence of local problems but it is a global issue, double binded to climate change, loss of biodiversity, rural poverty, and the migration of people to cities and across borders. Extreme land degradation and extreme poverty go hand in hand in drylands, where a combination of unsustainable land management and fluctuating weather conditions increase the vulnerability of the communities.

Land degradation is an environmental issue and, at the same time, a development issue. Sustainable land management is essential to both combating degradation of ecosystems and improving human well-being.

According to Toumi (Toumi, 2008), Moroccan agriculture main constraints are:

- Governance deficit: government intervention is inadequate to improve rural development;
- Land property/management: property laws are often unclear, causing obstacle to a proper management;
- Human factor: average age of agricultural workers is high, and so illiteracy. There is a limited use of mechanization and a decreasing youth interest in agricultural work;

- Inefficient water management: even if the water infrastructure is quite good, there are many wastes and inefficient uses;
- Production chain deficiencies: despite a constant improving and increasing potential, many production chains are not adequate;
- Institutional disorganization: state administration is fragmented at local level, resulting in bureaucratic problems, while cooperatives and associations represent only a minority of the producers.

Though these analyses were conducted several years ago, most of the issues persist unchanged, or even aggravated, despite the various efforts done to address them.

6.3 Stakeholders in the oases agricultural system

Table 5 contains a list of the main stakeholders involved in this study.

Table 5: main stakeholders in oases farming system development

Name	Type	Notes
Ministry of Agriculture, Fisheries, Rural Development and Forests	Public institution	The Ministry of Agriculture, Fisheries, Rural Development and Forests is responsible for developing and implementing the Government policy concerning Agriculture and Rural Development. It is the most important subject involved in almost all the major agricultural projects and strategies, like the *Plan Maroc Vert*, launched in 2008.
Ministry of Energy, Mines, Water and Environment	Public institution	The Ministry of Energy, Mines, Water and Environment is responsible for the development and implementation of government policy in the areas of energy, mines, and geology as well as control of other areas under its jurisdiction.
Ministry of Foreign Affairs and International Cooperation	Public institution	The Ministry of Foreign Affairs and International Cooperation is responsible for implementing Morocco's foreign policy and ensuring relations with foreign states.
Office National du Conseil Agricole (ONCA)	Public institution	ONCA is in charge of addressing, coordinating and monitoring the application of the Agricultural Council's strategy on National scale. It is mainly providing extension service to farmers.
Office Régional de Mise en Valeur Agricole (ORMVA)	Public institution	It is an operational branch of the Ministry of Agriculture, representing the Government on the territory. Each region has its office: for example, ORMVATF (Tafilalet) in Errachidia and ORMVAO (Drâa) in Ouarzazade, ORMVASM (Sous Massa) in Agadir. ORMVA supplies plantlets and technical support for training and awareness actions. ORMVATF has an agreement with the University of Meknés.
Office National de Sécurité Sanitaire des Produits Alimentaires (ONSSA)	Public institution	ONSSA is the institution responsible of the sanitarian protocols for plants, animals and food products.

Institut National de la Recherche Agronomique (INRA)	Public institution	INRA is a public research institution for agricultural development. It has 10 regional research centers and 23 experimental stations in the different Moroccan ecosystems. It works on pollination technique, biological pest control and varietal selection of date palm. It provides in vitro plantlets to farmers. It selected the Bayoud resistant variety "Nadja". There are two INRA centers working of date palm, one in Errachidia (production, genetics, irrigation, pathology and conservation) and one in Marrakech (value chain and processing).
Agence Nationale pour le Développement des Zones Oasiennes et de l'Arganier (ANDZOA)	Public institution	ANDZOA is a structure founded in 2010 and dedicated at fighting desertification and preservation of biodiversity. it is subject to the Ministry of Agriculture and Fisheries, with the task of protecting and developing the oasis environment and the Argan (*Argania spinosa*) production. Its interest is broader than only agriculture and includes tourism, ecology, etc. It is actually working on analysis and definition of indicators, not directly with farmers but through different partners. It is responsible of the Sustainable Oasis Initiative.
Agence pour la promotion et le développement économique et social des provinces du Sud du Royaume (ADPS)	Public institution	This agency assists national and local subjects, sustaining the development of the Southern area of the Kingdom. Its mission is to study and suggest development strategies, to coordinate the activities of various ministry departments and to search for the funding sources needed for sustaining, conceiving and implementing projects with social and economic impact. It is in charge of the *Progamme Oasis Sud* (POS).
Agence de l'Oriental	Public institution	The Agency's mission is to assist national and local subjects, sustaining the development of the Region Oriental of the Kingdom.
Direction de l'Aménagement du Territoire (DAT)	Public institution	DAT is a branch of Ministry of Urbanism, National Land Settlement, Housing & Policy of the City, in charge of development strategies and action plans. It is in charge of the *Programme de Développement Territorial Durable des Oasis du Tafilalet* (POT).
Université Moulay Ismail, Meknes	Public institution	The University, based in Meknès, has several Faculties in the region. A multidisciplinary faculty is based in Errachidia.
Region Drâa-Tafilalet	Public institution	One of the four Regions with important date production.
Region Oriental	Public institution	One of the four Regions with important date production.
Region Sous Massa	Public institution	One of the four Regions with important date production.
Region Guelmin-Oued Noun	Public institution	One of the four Regions with important date production.
German Corporation for International Cooperation GmbH (GIZ)	Cooperation agency	GIZ is taking on several commissions in Morocco for different clients, such as the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB), the Federal Foreign Office (AA), the Federal Ministry for Economic Affairs and Energy (BMWi), the European Union, and Moroccan companies. GIZ has two projects directly or indirectly related to date palm: Promoting employment through renewable energy and energy efficiency in the MENA region (RE-ACTIVATE) and Economic and rural development in disadvantaged regions of Morocco (PEDEL).
Belgian Development Agency (ENABEL)	Cooperation agency	ENABEL, formerly known as *Cooperation technique Belge* (CTB), implements Belgium's international development policy in Morocco, with various projects. It is responsible of the project *Appui et accompagnement des groupements d'intérêt économique pour le*

		développement de la filière phoenicole au niveau des oasis marocaines (PAGIE) and the project *Développement des filières du safran et du palmier dattier dans les régions Souss-Massa et Drâa-Tafilalet* (PDFSD).
U.S. Agency for International Development (USAID)	Cooperation agency	USAID is an independent agency of the U.S. Federal government. It is responsible for managing foreign aid policies and assistance programs.
Millennium Challenge Corporation (MCC)/Agency of Partnership for Progress (APP)	Cooperation agency	MCC is a bilateral U.S. foreign aid agency, responsible for the signing of bilateral agreement compact with foreign government. APP is the implementing agency of the projects developed inside the compact. APP is responsible of Morocco Fruit Tree Productivity Project.
Economic Interest Groups (GIE)	Consortium / Legal entity	A GIE is a consortium, formed by more cooperatives or associations, for economic purposes. It is a legal entity for the French law, and acts mainly as an interface with governmental institutions. Recently GIEs gained an active economic role, being in charge of the management of collective date storage and processing facilities.
Fédération Interprofessionnelle Marocaine des Dattes (FIMADATTES)	Producers association	Created in 2010, FIMADATTES represents producers from Ouarzazate, Figuig, Guelmin, Errachidia, Tinghir, Zagora and Tata, the most importat areas of date production. It is constituted by a *Production section* which has the colleges of Producers, of Nursery men and of Business, and of a *Valorization section* with the Colleges of Economic interest and of Commercialization and export. The Production section has 4 Regional Associations but only those of Sous Massa and Guelmin are active. It has union functions towards the Government institutions and coordination and training functions for associates.
Centre d'Etude et de développement des territoires oasiens et désertique (CEDTOD)	Association/ NGO	A liaison center between research, government services and farmers. Implements practical actions, actually is engaged in *khettara* rehabilitation and modernization, drop irrigation and other water provision methods development in Tafilalet oases. CEDTOD is based in Jorf municipality.
Réseau des Associations de la Réserve de Biosphère des Oasis du Sud Est Marocain (RARBOSM)	Association/ NGO	In November 2000, UNESCO recognize the union of the three provinces of Ouarzazate, Errachidia and Zagora, as *Réserve de Biosphère des Oasis du Sud Marocain*. RARBOSM is a network of associations involved in the preservation of this fragile ecosystem.
Coopératives Agricole	Cooperative	In the southern oasis most farmers are organized in cooperatives. As a general subdivision, it is possible to distinguish among production cooperatives and transformation cooperatives.
Farmers	Privates	Farmers directly involved in oasis farming system.
Landlords	Privates	Owners of land located in the oases that do not farm their plots directly, leaving them fallow or renting them or allowing others to exploit them.
Other	Various	National Initiative for Human Development Support Project (INDH), Civil society, Rural Municipalities, Provincial councils, Investors, etc…

6.4 The date palm in the oases farming systems

Inside the date production area, the four most important oases are: Errachidia, Figuig, Ouarzazate/Zagora and Tata (figure 8), where over 90 percent of domestic production is concentrated (APP, 201?).

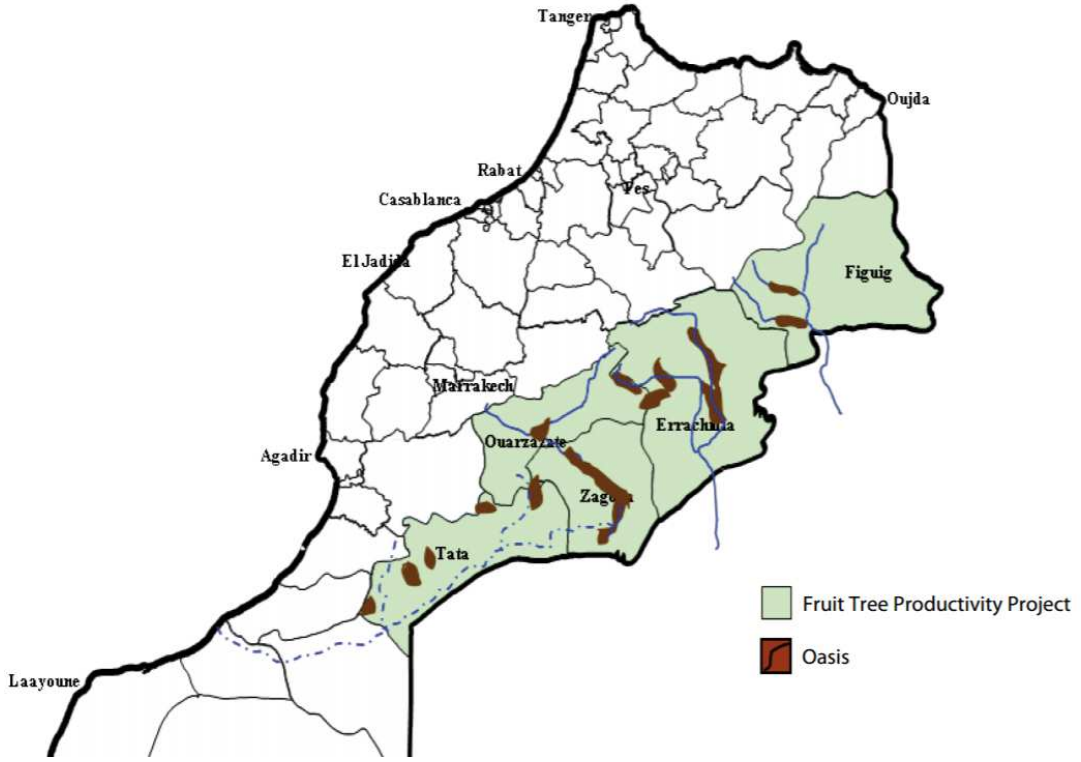

Fig.8: main areas of date cultivation (APP, 201?)

According to the Ministry of Agriculture, Fisheries, Rural Development and Forests, date sector contributes to 60% of the income for more than 1 million inhabitants of rural areas. Producers are estimated to be over 200,000, mainly small-holder farmers, of which about 10% are organized into cooperatives (APP, 201?).

All the stakeholders involved in the date production chain are represented by the *Fédération Interprofessionnelle Marocaine des Dattes* (FIMADATTES), created the 19/04/2010. FIMADATTES is not directly involved in agricultural operation, but it has union functions towards the Government institutions and coordination and training functions for its associates. FIMADATTES is organized in 5 different collegiums, subdivided in 2 sections.

The *Production Section* comprehends the stakeholders involved in the agricultural production, from plantation establishment to harvest. It includes 3 collegiums:

- Collegium Producers;
- Collegium Nurseries/Laboratories;
- Collegium Businessmen/investments.

The Valorization Section comprehends the stakeholders involved in post-harvesting and marketing operations. It includes 2 collegiums:

- Collegium GIEs;
- Collegium Traders/Brokers.

The collegiums are organized on country level, with the notable exception of the producers one, organized in 4 regional association: Drâa-Tafilalet, Guelmin-Oued Noun, Oriental and Sous-Massa (although they were recently created and only partially operative).

FIMADATTES has representative organism composed by 20 representatives of the collegium (8 for Producers, 1 for Nurseries/Laboratories, 1 for Businessmen/investments, 6 for GIEs, and 4 for Traders/Brokers).

It is unclear how many producers are currently part of FIMADATTES. From a theoretical point of view the federation represents all the Moroccan producers, but they should actively request to be registered to the regional associations. According to the estimation of FIMADATTES, the 60-70% of the producers already made request.

The main objective of FIMADATTES is to mediate internal conflicts, granting a good cooperation between the collegiums and promoting aggregation between all the stakeholders in order to pursue a common goal.

According to the Moroccan Ministry of Agriculture, Fisheries, Rural Development and Forests, the production of dates in 2016 reached around 125,000 tons distributed over 50,000 hectares. Table 6 shows date production statistics divided by provinces, while Table 7 provide some context, comparing date production with other crops production in the same regions.

Table 6: Date palm production statistics 2015/2016 (Ministere de l'Agriculture, de la Pêches Maritimes, du Développement Rural et des Eaux et Forêts, 2018)

Region	Provinces	Surface (1000 Ha)	Productive surface (1000 Ha)	Production (1000 T)
Drâa-Tafilalet	Errachidia	17.23	13.30	53.08
	Ouarzazate	2.75	2.20	5.41
	Tinghir	0.97	0.81	4.63
	Zagora	27.35	22.40	45.41
Guelmim – Oued Noun	Assa-Zag	0.23	0.22	0.57
	Guelmim	1.14	0.88	2.49
Oriental	Figuig	1.74	1.03	4.68
Sous Massa	Taroundant	0.06	0.06	0.03
	Tata	6.36	5.07	8.51
	Tiznit	0.28	0.12	0.5
	TOTAL	58.12	46.09	125.33

Table 7: general agricultural production statistics 2015/2016 (Ministere de l'Agriculture, de la Pêches Maritimes, du Développement Rural et des Eaux et Forêts, 2018)

	Drâa-Tafilalet		Guelmin – Oued Noun		Oriental		Sous Massa	
Crop	Surface (1000 Ha)	Production (1000 T)	Surface (1000 Ha)	Production (1000 T)	Surface (1000 Ha)	Production (1000 T)	Surface (1000 Ha)	Production (1000 T)
Cereal	103.59	200.61	7.10	n.a.	288.54	123.67	64.27	48.67
Legumes	0.79	0.85	-	-	3.71	2.59	0.111	0.08
Forage crops	9.25	55.48	2.03	581.700	17.64	681.32	1.92	127.07
Sugar crops	-	-	-	-	6.04	412.17	-	-
Primary vegetables	-	-	0.41	20.870	0.172	11.29	18.16	1,407
Sesonal vegetables	0.433	8.71	1.50	54.940	15.48	335.22	1.36	69.15
Almond	9.02	4.58	0.20	0.02	26.50	16.81	n.a.	27.94
Olive	13.12	14.94	2.14	3.10	117.04	207.38	19.06	19.80
Date palm	48.30	108.54	1.37	3.05	1.74	4.68	6.70	9.04
Citrus fruit	-	-	-	-	19.29	268.73	39.98	593.15
Fruit trees	25.74	400.57	0.04	2.40	11.20	117.56	5.53	72.46

Despite the importance of this crop the number of date palms has decreased dramatically in Morocco in the last century, passing from about 15 million to less than 5 million; the causes have been identified mainly in draught, advancing of the desert and pests that have not been properly addressed, also due to the decrease and aging in oasis population.

Recently, the *Plan Maroc Vert* has been defined to invert this trend, with two goals set: planting 3 million palms resistant to *Bayoud* in 10 years (from 2010 to 2020) and make Morocco a date

exporting Country, producing 185,000 tons in 2030 (*Ministere de l'Agriculture, de la Pêches Maritimes, du Développement Rural et des Eaux et Forêts*, 2018).

Proving the good will of *Plan Maroc Vert*, both land surface and date production have increased during the last 10 years, except in Sous Massa region, where the land surface slightly decreased, as reported in table 8. Unfortunately, this improvement did not happen through restoration of degraded oasis plantation, but through the establishment of completely new modern plantations.

Table 8: Evolution of date palm surface and production between 2008-2016 (Ministere de l'Agriculture, de la Pêches Maritimes, du Développement Rural et des Eaux et Forêts, 2018)

Region	**2008/2009**		**2015/2016**	
	Surface (1000 Ha)	**Production (1000 T)**	**Surface (1000 Ha)**	**Production (1000 T)**
Drâa-Tafilalet	39.98	86.5	48.30	108.54
Guelmim – Oued Noun	1.28	0.5	1.37	3.05
Oriental	1.33	1.5	1.74	4.68
Sous Massa	8.4	1.92	6.70	9.04
Total	50.99	90.42	58.12	125.33

Modern plantations are usually established outside the oasis perimeter, without sharing the traditional three-layers structure. A modern plantation is usually a date palm monoculture, where palms are planted in a regular grid (6x6m) and the ground is maintained uncovered to help the movements of machines and the establishment of a drip irrigation system. Sometimes date palm can be associated with olive trees (planted in close rows on separate plots) or other fruit trees (like pomegranate, as interrow between palms).

Modern plantations usually do not rely on traditional water sources, but almost entirely on private deep wells and pumping stations. Works can be both manual or mechanized, depending on the age and height of the plants, but in general is more heavily mechanized than the traditional system.

Modern plantations serve a purely commercial purpose, with no positive effect on the oasis ecosystem. In fact, they could also represent a future ecological threat, lacking a serious analysis on the impact of deep aquifer overexploitation.

6.4.1 Date palm varieties in Morocco

Moroccan production comprehends about 20% of high quality dates and about 70% of mediocre quality dates, that should be better valorized by transformation process (Sedra, 2003).

Among numerous existing date palm varieties (223 are known while the unnamed hybrids, referred to as *Khalt* are estimated to be about 1,800), the best-known local, indigenous varieties are *Bou-Feggous*, *Bou-Skri*, *Jihel*, and *Mejhoul* (APP, 200?), but many others are commonly appreciated by local consumers.

According to the Moroccan Ministry of Agriculture, Fisheries, Rural Development and Forests, the *Khalt* accounts for 47,7% of national production, while, among the most appreciated varieties, *Jihel* (11,9%) is the most important while the world famous *Mejhoul* accounts only for 0,3% of the total production. Taking into account the market price the most valuable is *Mejhoul*, followed by *Bou-Feggous*, *Bou-skri*, *Aguelid*, *Jihel*, *Bou-Rar*, *Race-Lahmar*, *Bou-Cerdoun*, *Bou-Sthammi*, *Iklane* and *Ahardane* (Bendiab et al., 2008; APP, 200?). These figures are likely to change in the next years due to the fact that the new intensive specialized and mostly monovarietal date plantations, rapidly developing at the oases outskirts, are mainly of the *Mejhoul* variety and only in some cases, also few other valuable varieties are planted. The recently developed *Nadja* variety, who resists *Bayoud*, could also take place in some heavily infested areas.

Table 9: lists some important Moroccan date varieties (Bendiab et al., 2008; INRA 2011).

Variety	Characteristics							Origin
	Colour	Period	Resistance	Productivity	Type	Quality	Height	
Ademou	Light Brown	Medium	Susceptible	Medium	Dry	+++	High	Drâa, Tafilalet
Aguelid	L.Brown	Early	Medium resistant	Medium	Semidry	+++	Medium	Drâa, Bani, Saghro, Anti-Atlas
Ahardane	L.Brown	Early	Very Susceptible	Low	Semidry	++	Low	Drâa, Bani, Saghro, Anti-Atlas, Oriental
Aïssa-Lyoub	L.Brown	Late	Susceptible	Medium	Semidry	++	Medium	Drâa, Oriental
Azegzao	L.Brown	Early	Medium resistant	Low	Semidry	+	Low	Saghro, Sag-HautAtlas, Tafilalet, Ferkla, Gheris
Aziza	L.Brown	Medium	Susceptible	n/a	Semidry	++	High	Oriental
Bel-Hazit	L.Brown	Medium	Susceptible	Medium	Semidry	++	Low	Tafilalet
Bou-Cerdoun	L.Brown	Medium	Susceptible	Medium	Dry	+++	Low	Saghro, Sag-HautAtlas, Oriental, Tafilalet, Gheris
Bou-Feggous	Dark brown	Medium	Very susceptible	High	Soft	++++	Low	Everywhere
Bou-Feggous ou Moussa	Red black	Early	Resistant	High	Soft	+	High	Bani
Bou-Ijjou	L.Brown	Medium	Susceptible	Medium	Dry	++	Low	Oriental, Tafilalet, Guir

Bou-Ittob	L.Brown	Late	Susceptible	Medium	Dry	++	Low	Bani, Anti-Atlas
Bou-Rar	D.Brown	Late	Very susceptible	Medium	Semidry	++++	Medium	Drâa, Bani, Saghro, Tafilalet
Bou-Skri	D.Brown	Late	Susceptible	Medium	Dry	+++	Low	Drâa, Bani, Saghro, Anti-Atlas, Sag-HautAtlas, Oriental, Tafilalet, Todra
Bou-Slikhène	L.Brown	Early	Medium resistant	Medium	Semidry	++++	Medium	Saghro, Tafilalet
Bou-Sthammi Noire	Red black	Late	Resistant	High	Soft	+++	High	Drâa, Bani, Saghro, Sag-HautAtlas, Anti-Atlas, Tafilatet
Bou-Sthammi Blanche	D.Brown	Medium	Resistant	Medium	Soft	++	Medium	Bani, Anti-Atlas
Bou-Temda	D.Brown	Early	Susceptible	Medium	Semidry	++	Low	Bani
Bou-Zeggar	Red Black	Late	Medium resistant	High	Semidry	++	High	Drâa, Sag-HautAtlas, Gheris, Fer-Kala
Houa	L.Brown	Medium	Susceptible	Medium	Semidry	++	Low	Drâa, Tafilalet
Iklane	Red Black	Late	Resistant	High	Semidry	+	Medium	Drâa, Bani, Saghro, Anti-Atlas
Jihel	L.Brown	Late	Very susceptible	High	Dry	++	Medium	Drâa, Bani, Saghro, Anti-Atlas, Sag-HautAtlas, Tafilalet
Mah-Lbaid	L.Brown	Late	Susceptible	Medium	Soft	+++	Medium	Drâa, Bani, Anti-Atlas
Mejhoul	D.Brown	Late	Susceptible	Very High	Semidry	+++++	Low	Drâa, Bani, Tafilalet, Oriental, Ziz
Mekt	Red black	Medium	Susceptible	Medium	Soft	++	Low	Drâa, Bani, Saghro, Anti-Atlas
Mest-Ali	D.Brown	Early	Susceptible	Medium	Semidry	++++	Medium	Drâa
Najda	L.Brown	Medium	Resistant	n/a	Semidry	++++	High	Everywhere
Otoukdime	L.Brown	Late	Medium resistant	Medium	Dry	+++	Low	Saghro, Sag-HautAtlas, Todra
Oum-N'hale	L.Brown	Late	Susceptible	Medium	Semidry	++++	Medium	Drâa, Anti-Atlas
Race-Lahmar	L.Brown	Medium	Susceptible	Medium	Dry	+++	Medium	Drâa, Bani, Saghro, Sag-HautAtlas, Tafilalet

Sair Layalet	L.Brown	Late	Resistant	High	Semidry	+++	Medium	Bani
Tademainte	Red blak	Medium	Resistant	Medium	Semidry	+++	High	Drâa, Bani, Saghro, Anti-Atlas, Oriental

According to the APP Fruit Tree Productivity Project, the Moroccan date production is characterized by inconsistent quality and quantity, and poor packing, with the majority of sales occurring in informal markets at low prices (APP, 201?).

There is strong demand for high-quality dates in Morocco. Current consumption of dates is inferior to the estimated demand, and unmatched by the total domestic production. In 2008, domestic consumption was around 120,000 T, while the total demand was estimated to be 160,000 T (APP, 201?). Even if in the last 10 years the domestic production is growing, there is still a significant unmet market demand. Morocco has a low domestic supply of high-quality dates and the majority of the production is available only shortly after the harvest, due poor post-harvest handling and packaging.

Tunisian dates dominate the middle to high-end market for dates in Morocco, especially with *Deglet Noor*, the only variety available all year-round in Moroccan supermarkets. Taste tests have shown that Moroccans strongly prefer locally grown date varieties, and are often willing to pay higher prices for them. The highest price corresponds with the peak of demand, during the Ramadan, but if it falls too far from the harvest period, Moroccans consumers are forced to buy imported dates (APP, 201?).

6.4.2 The date palm production chain

Date production is a complex operation, requesting much attention, and traditionally labor intensive. Date palm is dioecious, with different male and female plants, an important factor conditioning the agricultural operations.

Tending operations (Sedra 2003):

- Multiplication: date palm can be multiplied by seeds, shoots or *in vitro* tissue culture, depending on the goals and needs. Multiplication by seed is used for breeding programs while the other methods, which produce clones, are more suited for commercial multiplication.
- Transplanting: it is needed in order to renovate or establish a new plantation. Both young and adult plants can be transplanted, even if in the second case much more attention is needed.
- Irrigation: traditionally, irrigation is carried on simply by gravity, utilizing irrigation channels and small ditches, or by submerging the entire plot. In modern, commercial date palm plantations the more efficient drip irrigation is used. Water is collected from main public

channels, from catchments installed along water courses and from wells. In modern plantations low rate bore wells are used and water is collected in artificial open basins.

- Fertilization: traditionally it was granted by plant residues and manure from the livestock, nowadays a more efficient use of fertilization is required to maintain the soil fertility and a good production and chemical fertilizers are often used. The methods of application can vary, also depending on the irrigation system.
- Weeding: in general, it is recommended to avoid competition, make the palm more accessible and avoid shelter for pests. In traditional plantation, where other annual crops are present under the palms, it is a selective operation. In modern plantation the ground is maintained completely uncovered to make the movements of machines and the establishment of a drip irrigation system simplest.
- Pruning: to remove older leafs and leaf sheathings together with other dead parts in order to make access to fruits easier and avoid insurgence of diseases.
- Pollination: even if the female date flowers are naturally pollinated by wind, pollination is carried on artificially in order to increase the productivity, both in traditional and modern commercial plantation. The pollination can be manual, semi-mechanized or totally mechanized, according to the organization of the plantation. Traditional manual method is slow and very dangerous for the worker that has to climb up the palm and tinker with the inflorescences.
- Spraying: the spraying of various chemicals is recommended in order to deal with date palm pests and diseases, although small producers often prefer to rely on removal of infected palm, strict quarantine measures and use of resistant varieties, more than invest heavily on spraying.
- Arranging of fruit bunches: the bunches are arranged unraveled on the leaf stalks for support and in order to make subsequent operations easier.
- Thinning of fruits: it is recommended for increasing growth during the first years and for increasing fruit size and quality.
- Bagging: to prevent damage from rainfall or humidity and, in some cases from birds, fruits are often protected by covering them totally or partially with plastic or paper bags or plastic nets.
- Harvesting: according to the variety and the organization of the plantation it can be carried on by picking dates one by one or the whole bunch. In some cases, the fruit bunches are shaken and dates collected on tarpaulins laid on the ground. The operation is traditionally done manually, by a specialized worker climbing up the palm and has to be repeated several

times for each plant. It is one of the most important phases, highly conditioning the final product quality.

- Selection: according to quality, different ripeness stages and moisture content, fruits are sorted and selected for the local market, international market of transformation chain.

All the operations where climbing up the palm is required represent a risk for the worker safety and a slowdown of the production chain. This also represents a crucial point of intervention for improving the production chain.

Post-harvesting operations (Sedra 2003): Depending on the variety, some dates can receive additional treatment (for example a brief sun dry to reduce moisture content), but the majority of Moroccan dates are brought into the packing house directly after harvesting, in some cases they are even packed at the harvesting site.

- Cleaning
- Selection
- Packaging: the type of packaging can vary depending on the commercial target. The *in situ* packaging aims at reducing product losses and is consequence of missing of adequate infrastructures.
- Storage: depending on moisture content dates can be easily stored in a refrigerator for a quite long time, with a temperature between 0-21°C and a relative humidity of 65-70%. The common temperature is around 4°C, but unfortunately, many producers don't have an adequate storage infrastructure.

Table 10: Optimal temperature for dates conservations (Sedra 2003)

Temperature °C	Conservation time
26/27	1 month
15/16	3 months
4/5	8 months
-2/-3	1 year
-17/-18	>1 year

- Transformation: unappreciated variety, and damaged fruits are used for jam, syrup and pâté production, while more fibrous variety are used for flour production. Transformation facilities can be private or collectives.
- Commercialization: The commercialization phase is usually based on informal relations between producers and traders. Small farmers and cooperatives are unable to access the organized large-scale distribution, and usually sold their products on the local market, festivals

or in some collective market areas created by the government for the selling of local products. Only big cooperatives, GIEs and big producers/businessmen are able to establish long term agreement with organized large-scale distribution and export their products.

The packaging and the storage phase are felt as the main weaknesses of the post harvesting operations (Sedra 2003). In order to face these problems, in recent years ORMVA built a series of common storage units, inside the second pillar of PMV. The first bunch were funded by MCC, inside the Morocco Fruit Tree Productivity Project. An additional series of storage units seems to be planned inside the first pillar of PMV, funded by Moroccan government, but it is still not realized (*Chambre d'Agriculture de la Région Drâa-Tafilalet*, 2017).

For example, in Drâa-Tafilalet region, the overall objective was the construction of 27 storage units, for a total storage capacity of 3,920 t. However, MCC funds covered only the building of 17 units, for a storage capacity of 3,540 t, as shown in table 11. The other units are waiting additional funds from other sources in order to purchase the equipment, and in some cases, in order to build the entire structure (*Chambre d'Agriculture de la Région Drâa-Tafilalet*, 2017).

Table 11: Date storage unit distribution in the Drâa-Tafilalet region (Chambre d'Agriculture de la Région Drâa-Tafilalet, 2017)

	Errachidia		Ouarzazate		Tinghir		Zagora		Total Regions	
	Planned	Realized	Planned	Realized	Planned	Realized	Planned	Realized	Planned	Realized
N° of units	10	5	1	1	2	2	13	9	27	17
Total storage capacity (t)	1,950	1,640	100	100	120	115	1,750	1685	3,920	3,540

The storage units built by ORMVA are all based on the same project and they are theoretically equivalent one to another, even if the storage capacity can vary between 100-400 t.

The storage units are managed by GIEs. Each unit needs 1 director, 1 guardian, 4 administrative employers, 10-80 workers (depending on the peak of production). Often the personal of ONCA has an office inside/near the unit, in order to support the work of the GIE, raising awareness among producers about the importance of storage.

Fig. 9: Storage unit of the Mergouna GIE near Rissani (Photo credit: Garbati Pegna)

Storage operations:

- Delivery;
- Weighing;
- 1° selection/evaluation (visual exam): dates are accepted or refused;
- Fumigation: each storage unit has 2 fumigation chambers, theoretically isolated by the rest of the structure. Dates are fumigated immediately upon arrival, after weighting, before the selection is carried out. Fumigation is done with phosphine in airtight chambers for 3-5 days depending on variable parameters, being temperature the most important;
- 2° selection (dimension and variety): each unit has a conveyor belt line, but it is not always operative, in this case the operation is carried on completely manually;
- Storage: dates are stored in cold rooms at 0-4 °C. Before storing in cold rooms and immediately after dates are left in the antechamber for 24 h at 15 °C for a better settling of the temperature;
- Washing (dates and boxes): just before the selling, dates are washed (most precious varieties sometimes are also glazed with sugar, to increase the appealing). The process is mechanized with two machines, one for the dates and one for the plastic boxes;
- Drying: there are two electric dry machines/ovens for this operation, unfortunately the lack of boxes and specific cart make difficult the loading of the machine;
- Packaging: the operation is partially manual and partially mechanized.

At the moment there is no defined protocol for the management of the storage units, so each GIE can choose the way it prefers. According to the interviews carried on in February 2017, there are three possible options, with small variations:

- Storage service: the GIE offers the service to cooperatives or single producers. The service costs an average of 1.5-2 Dh/kg for "season" and lasts for 6-9 months, or in alternative 0.3 Dh/kg for a single month. Usually dates are stored until the period of the Ramadan, during which the demand grows and the price are higher;
- Storage and marketing services: this option is complementary to the first one. In addition, the GIE acts as broker between producers and buyers. After receiving a price proposal, the GIE forwards it to the producer/cooperative that is free to accept or refuse it. The service cost is composed by the cost of the storage service plus about 2 Dh/kg for selection and packaging (the percentage of gain among different GIEs can vary);
- Buying and Selling service: after negotiating a price with the cooperatives (usually higher than the market price), the GIE buys the entire production and sells it as its own. All the extra gain belongs to the GIE. For the packaging the GIE can use its own label or the one of the buyer (see Fig. 10).

The second and third option seem to be the most appreciated by producers, making the marketing a lot easier for them. Unfortunately, GIEs usually do not have big capital and the Buying and Selling service is possible only through access to credit.

Fig 10: Different packaging options at GIE Difat Ziz, Erfoud/Jorf (Photo credit: Bartolini)

7 FARMING SYSTEM DIAGNOSIS

7.1 Oases selection and field survey

An important zone in the pre-Saharan and Saharan eco-systems, where cultivated plots of different sizes are common, is along and between the Drâa and Ziz wadies which includes also the Todra and upper Gheris wadies. According to ORMVA esteems, there are around 40,000 date producers in Drâa, and 40,000 in Tafilalet. The average land surface for each producer is far below 1 ha, also considering the land accumulation for modern plantation by big investors.

In this area 17 localities were selected for field surveys and interviews to farmers; in addition, 3 locations were selected also in the Tata province, another area where date production plays and important role and important oases are located. More south-west the oasis of Taghjicht was selected while, at the eastern extreme of the date production area, also the oasis of Figuig was taken into consideration. The list of the oases where data collection has been carried out is contained in Table 12. All oases, with the exception of Figuig, were visited and a brief description was drafted, based on interview to farmers or other local stakeholders (Farmers' interview form in Annex 1). Information about Figuig palm groves was collected by interviewing farmers from that area at the Salon International des Dattes au Maroc (SIDATTES) in Erfoud in October 2017. Interviews aiming to better understand the oases characteristics, their problems and possible useful interventions, were also carried out with institutional stakeholders (Institutional interview form in Annex 2); a list of interlocutors is reported in Table 13.

Table 12: list of oases selected for survey and interviews

N.	Name	Province	Region	Water source
1	Skoura	Ouarzazade	Sous-Massa-Draa	Dades/Ouarzazade
2	Agdz	Ouarzazade	Sous-Massa-Draa	Draa/Zagora
3	Zagora	Ouarzazade	Sous-Massa-Draa	Draa/Zagora
4	Taamegroute	Ouarzazade	Sous-Massa-Draa	Draa/Zagora
5	Lblida	Ouarzazade	Sous-Massa-Draa	Draa/Zagora
6	M'Hamid	Ouarzazade	Sous-Massa-Draa	Draa/Zagora
7	Goulmina	Errachidia	Tafilalet	Gheris
9	Errachidia	Errachidia	Tafilalet	Ziz/Errachidia
10	Boudenib	Errachidia	Tafilalet	Guir
11	Tinghir	Ouarzazade	Sous-Massa-Draa	Todra
12	Souk El Khémis	Ouarzazade	Sous-Massa-Draa	Dades

13	Aoufous	Errachidia	Tafilalet	Ziz/Errachidia
14	Erfoud	Errachidia	Tafilalet	Ziz/Erfoud
15	Jorf	Errachidia	Tafilalet	Ziz/Erfoud
16	Rissani	Errachidia	Tafilalet	Ziz/Erfoud
17	Ramlia	Errachidia	Tafilalet	Ziz, Gheris
18	Tissint	Tata	Sous-Massa	Groundwater
19	Figuig	Figuig	Orientale	Groundwater
20	Tata	Tata	Sous-Massa	Groundwater
21	Akka	Tata	Sous-Massa	Groundwater
21	Taghjicht	Tiznit	Guelmim-Es Semara	Groundwater

Table 13: list of interlocutors contacted during survey and interviews

Institution			
Type	**Name**	**Activity**	**Location**
Public institution	Agence Nationale pour le Développement des Zones Oasiennes et de l'Arganier (ANDZOA)	Support to development strategies in the region. It is working with INRA at the satellite mapping of the Moroccan Oases and the improvement of storage techniques, it works with ORMVA at the construction of the storage units and the creation of regional labels, and constantly support the activities of FIMADATTES.	Errachidia
Public institution	Institut National de la Recherche Agronomique (INRA)	Errachidia office works on several topics: irrigation/fertirrigation, Bayoud disease, biological control, genetic improvement, in vitro culture, appropriate storage techniques, and use of by-product.	Errachidia

Public institution	Office National du Conseil Agricole (ONCA)	ONCA maintains direct contact with producers and local associations, thanks to vast network of local offices offering technical support.	Errachidia
Public institution	Office Regional pour la Mise en Valor Agricole du Tafilalet (ORMVATF)	Responsible for agricultural policies in Tafilalet region, corresponding approximatively to the province of Errachidia, Midelt and Bouafra.	Errachidia
Association			
Type	**Name**	**Activity**	**Location**
Association/NGO	Centre d'Etude et de développement des territoires oasiens et désertique (CEDTOD)		Jorf
Producers association	Fédération Interprofessionnelle Marocaine des Dattes (FIMADATTES)		Errachidia
GIE	Alnif Tafraoute Maider	Recently created, no collective operations	Alnif, Tinghir
GIE	Difat Ziz	Storage, marketing	Erfoud/Jorf
GIE	Kamaran	Storage, field ops.	Jorf

GIE	Mergouna	Storage, marketing	Rissani
GIE	Ouhmidi Al Kobra	Storage, marketing	Ouarzazate
GIE	Palmeraie Ternata	Storage, marketing	Zagora
Cooperative	Afra	Storage, processing, marketing (only part of the production, 50 t)	Tata
Family cooperative	Al Faiz	Production, storage, processing, marketing	Figuig
Female cooperative	Cooperative artisanale de solidarite pour la production et la commercialization des produits locaux	Processing (date is marginal activity)	Figuig
Cooperative	Cooperative agricole Taourirt	Production, marketing (storage rented from Tata or Zagora)	Guelmin
Cooperative	Dattes Al Asala	Storage, marketing	Tagounit
Cooperative	Ohati*	Production, processing	Aoufous
Female cooperative	Wahadi	Processing, marketing	Aoufous
Cooperative	Zrejet	Processing	Blajhma
Cooperative	Zrigat	Processing, storage, marketing	Aoufous

Landlord	Ali Addarkaoui	Production (date production seems a marginal activity)	Ksar Tazwakte
Landlord	Mohamed Idrissi	Production	Tinejdad
Landlord	Mustapha Addarkaoui	Production	Errachidia
Farmer	Taher ben Brahim	Production	Boudinib
Farmer	Mohamed Boushaba	production	Aoufous
Farmer	Said Ougoru	Production	Goulmina
Farmer	Karim Charouit	Production, marketing	n.a.
Farmer	Moulay Ali Taha	Production	Tagounit

* Started by USAID

Some cooperatives are constituted only by women while other are mixed. Generally, in mixed the cooperatives men do the heaviest work especially in the field, manage the business, while women do works that require more neatness. Women cooperatives are often encouraged by cooperation interventions as a response to a persistent gender bias, that relegate women in subaltern roles in mixed cooperatives.

7.1.1 Characteristics of the date palm chain in the visited groves (from surveys and interviews)

Date palm groves exist in this environment since centuries and have been cultivated more or less in the same way until few decades ago. The land is privately owned and farmers cultivate it individually with the family work force, though many are organized in cooperatives for making the value chain more efficient.

Nowadays the profitability of these groves has fallen due to the complexity of their management that is worsened by the scarcity of labor and the decline of water availability and quality. This leads to a vicious circle where investments are no longer done and productivity decreases. In some cases, the situation is worsened by the advancing sand dunes that concurs to the abandoning of these traditional settings (see Fig. 11). Moreover, older palms in traditional groves are tall and of low quality and it isn't worth to rehabilitate them though, value adding interventions such as processing and marketing, could improve the situation.

Fig. 11: Advancing sand dunes, menacing a palm grove along R702 near Jorf municipality, in Errachidia province (CEDTOD, 2018)

A widespread practice for solving the problems affecting older traditional plantations is to abandon them and plant new intensive and specialized parcels nearby, adopting modern techniques and planting only few selected varieties. Although this solution proves to be profitable, it causes severe loss of biodiversity and cultural heritage.

Fig 12: A newly established plot, outside the oasis boundaries in Tagounite (Photo credit: Garbati Pegna)

7.1.1.1 Structure

Property is usually fragmented with many producers owning small and, in some cases strewn parcels.

In general, we can divide the producers in 3 categories:

- Farmers: agriculture is the primary source of income and food for the family. The plantation is usually managed in a traditional way, with a polyculture structure;
- Investors: they could be local or foreign people. Investors own medium/big plantations characterized by monoculture (date palm and olive tree) and modern management, often oriented to exportation;
- Farmers of convenience: this category is not easy to be defined. For them agriculture is not the primary source of income. According to the wealth of the farmer, the land could be inherited or bought/rented on purpose and the plantation could be modern or traditional. Usually, the management is limited to the basic needs, because in the region date production is considered an easy investment. Palms request low inputs, low labour, granting a good income without great risks (especially selling the production directly on the palm).

In this period, the most popular date varieties are *Mejhoul*, *Bou-Feggous* and *Najda* but, since plantlets are provided by public Institutions at subvention prices, farmers normally plant whatever is available at the moment. *Mejhoul* is far the most valuable variety but due to the higher cost it has a more limited market, while *Bou-Feggous*, though being softer and more delicate, is an everyday date and is experiencing an increasing popularity.

Palms are rarely planted in regular frames but most frequently sparsely scattered in the groves. This is because the original patterns, where present, have gone lost, but also because of the intrinsic characteristics of date palm cultivation in limited space. In fact, when a palm dies or becomes too tall for being attended, it can't be replaced in a short time, due to the persistence of the stump, so new palms are planted where space is available; moreover, farmers are reluctant to voluntarily eliminate plantlets developing from seeds. More recently the widespread lethal *Bayoud* disease has aggravated the situation wiping out many of the most valuable palms and causing discouragement and loss of will to replant hence causing increase of the bare areas where sprouts from seeds can easily thrive or where farmers attempt cultivating annual crop (see Fig. 13).

Fig. 13: Palm grove along the Ziz Oued, between Errachidia and Aoufous, with bare areas due to *Bayoud* devastation (Photo credit: Garbati Pegna)

In many cases date palms of different ages are confined along the borders of the arable parcels and along the channels or scattered in those that once were specialized plots and where dead plants have not been replaced.

The height of the palms depends on the variety and on the age; most palms are in the range height of 4-6 m with some reaching up to 8-10 m, but also higher palms are present, which are no longer attended.

Palms are usually surrounded by many shoots of different ages, that have not been eliminated and have, in some cases, transformed many palms into bushy agglomerations (see Fig. 14); even shoots of valuable varieties are often not collected, probably due to the fact that farmers distrust shoots, that can be infected by *Bayoud*, and prefer to plant in-vitro produced plantlets, also because of public subsidies.

Fig 14: Poorly tended grove near *Ksar* Tazwakte (Photo credit: Bartolini)

Olive tree is the second most important crop after date palm, and it is present in most groves. In traditional plantations, olive trees are usually planted along the border of the parcel, and farmers produce oil for their own consumption, usually utilizing traditional stone grinding machines. In modern plantations, olive trees are planted in rows, suited for mechanized operations. The production is sold as fruit or as oil, according with the infrastructure available in the plantation.

Other relevant tree crops, both for auto-consumption and to be sold on the market, are: pomegranate, almond, peach, apricot, apple, orange, lemon and quince. Pomegranate is usually planted between the palm rows, because it seems to have positive effects contrasting pests and diseases, other trees have a more scattered pattern.

Arable land is always present between palms rows but only in some cases it is convenient to cultivate it. In recent time, after the devastation of the *Bayoud* disease, many abandoned plots inside the palm grove were converted to field crops monoculture. Wheat, Corn, legumes and alfalfa are the most important crops, cultivated for human and animal consumption.

Many small producers have some livestock, brood under the palm. Livestock usually includes goat of local breed called *D'eman*, a few cows and some chickens, ducks and turkey. These animals

are brood almost exclusively for auto-consumption, except for goats, a small number of which is sold in the market in occasion of *Eid al-Adha*.

Irrigation water is drawn from wells, that serve one or different farms, or from concrete or earth open channels that belong to a centralized distribution system where water is distributed according to calendars. In some cases, water is tapped from sources or directly from wadies, while most of the traditional *khettara* systems are no longer working.

The rare new farm buildings are made of concrete bricks while the older ones are made of mud bricks and modifications and repairs are made using material from collapsed antique *ksour*. The average cost is around 1,000 MAD/m^2.

Traditional groves are usually easily accessible and well served by a dense road network, only in abandoned groves bushes and sand can hinder the passage.

7.1.1.2 Technical characteristics

Management practices can vary widely, according to the producer, but in general we can distinguish between traditional (Table 14) and modern plantation (Table 15).

Table 14: Traditional farming system agricultural operations

Agricultural operation	Done? Yes/No/Seldom	Type of management	Tools:
Collection of off-shoots	Seldom	Manual	
Landworks (plowing/harrowing/tillage)	Yes	Manual/Mechanized	Tractor with plow/harrow
Irrigation	Yes	Traditional/mechanized	Chanel by gravity, drip irrigation from basin with solar water-pump
Pruning	Yes	Manual	Stair/Safe belt*
Pollination (palm)	Yes	Manual/Mechanized	Unknown
Cleaning (of palm/trunk)	Yes	Manual	Stair/Safe belt*
Thinning (palm)	Yes	Manual	Stair/Safe belt*
Fruit protection (palm)	Yes	Manual	Stair/Safe belt*, protection sacks
Fertilization	Seldom	Manual	Manure
Treatment	No**		
Harvesting (palm/tree)	Yes	Manual	Stair/Safe belt*
Harvesting (field crop)	Yes	Manual/Mechanized	Brush cutter
Transport	Yes	Animal labour/Mechanized	Donkey/truck

* Stairs and safe belts are not so common, even if especially young people doesn't want to risk their live on top of a palm.

**Small farmers do no treatments.

Table 15: Modern farming system agricultural operations

Agricultural operation	Done? YES/NO	Type of management	Tools:
Collection of off-shoots	Yes	Manual	
Landworks (plowing/harrowing/tillage)	Yes	Mechanized	Tractor with plow/harrow
Irrigation	Yes	Mechanized	Drip irrigation from basin, with solar water-pump
Pruning (palm)	Yes	Manual	Safe belt
Pruning (olive tree)	Yes	Mechanized	Unknown
Pollination (palm)	Yes	Manual/Mechanized	Unknown
Cleaning (of palm/trunk)	Yes	Manual	Safe belt
Thinning (palm)	Yes	Manual	Safe belt
Fruit protection (palm)	Yes	Manual	Protection sacks
Fertilization	Yes	Manual	Unknown
Treatment	Yes	Manual/Mechanized	Unknown
Harvesting (palm)	Yes	Manual	Safe belt
Harvesting (olive)	Yes	Mechanized	Unknown
Transport	Yes	Mechanized	Truck

In general, there is a limited use of mechanization in date plantations, even if the reasons of this choice are different between traditional and modern farming systems. Traditional farms usually are divided in many plots and have no space to organize a proper mechanization. Old palms are scarcely or not at all tended, and sometimes not harvested, however maintained in place even if considered not productive. On the contrary, modern plantations, even having adequate space, maintain the palms of small dimension through a constant renewal, allowing easy manual operation.

Cultivation operations are rare, in some cases palms near to arable plots benefit from little tillage and fertilization dedicated to annual crops. Only palms of valuable varieties receive some attention and are regularly pruned, pollinated and sometimes even sprayed. Manure, when available, is spread on top of the parcels but not mixed up with the soil, hence exposing it to fast mineralization and loss of nutrients. Tillage, where not hindered by parcel fragmentation, it is done with contracted tractors and toothed cultivators, no other operation is mechanized except for transport that, if not done by donkeys, relies on three-wheelers or small trucks.

All operations at the fronds level are done manually by climbing with the aid of a belt, a tiring and dangerous operation. Every year someone dies and many are injured by falling down, as testified by many interviewed farmers. For this reason, climbers are difficult to find and harvest is often retarded with consequent production loss. Especially young people are not willing to risk their lives

climbing palms. This fact affects also pollination and bagging, both laborious operation when carried out in the traditional way. Neglecting those operations reduces fruit set and fruit quality.

In order to improve safety in aerial operations, ORMVA has provided aluminum ladders to the farmers. Some of them were donated to the GIEs, others are at disposal in the local offices by a simply registration. The ladders are considered useful and due to the task but there are in a limited number and seldom used by the majority of the farmers.

As we observed in Rissani, sometimes even lower palms are not pruned and the leaf sheaths are left on the stem constituting a shelter for insects and other pests. Some palm groves, being untended since long time, have turned into scrub and are sometimes referred to as “forests”. All this negatively influences the amount and quality of production.

When a palm is suspected to be infected by *Bayoud* it is often set on fire, since this practice is believed to disinfect the palm without killing it. As a matter of fact, most palms eventually recover after some time, but there is no certainty that the disease has been eliminated.

Parcels are watered with surface irrigation, by flooding or by watering furrows; the irrigation systems are shared by the farmers according to local or standard agreements, water is often of low quality, rich in minerals and must be managed carefully. Where wells are used the water is pumped with by submerged electrical or mechanical pumps mostly driven by PV systems in the first case and by endothermic engines in the second one. PV systems are becoming popular in new installations because of the Government sustain, while the older ones are still based on the fossil fuel engine connected with belts and shafts to mechanical pumps. The electrical pumps normally have low flow rates so buffer basins are needed though in other cases water is pumped directly into the channels or the fields. The smaller thermal engines, used also for pumping the water out of the basins and to the fields, are 4-stroke gasoline powered, often converted to run on propane, the larger ones 4-stroke Diesel of the slow speed Lister type.

Renovation of irrigation equipment is quite exceptional in old groves and where it occurs solar systems are considered the best option, mostly because of the fact that investment is subsided and running costs are very low, while operating on fossil fuels, even if propane is used, is seen as quite expensive.

The farmers and the government fight the advancing of the dunes by building walls and planting tamarisks (*Tamarix* spp.) but often the choice is to set up new plantations a little further since

due to the government subsidies, planting new groves is often easier than tending older ones that moreover are in large part constituted by low value *khalts* though, more recently with the setting up of the GIEs and storage centers, *khalts* have increased their value and are considered with more interest by the farmers.

Dates in Morocco are typically harvested completely ripe and require little or no post-harvest drying. As common practice, harvested fruits are spread or piled on tarpaulins laid on the ground inside the grove where some rough selection is done (see Fig. 15).

Fig. 15: Harvesting and triage of dates near *Ksar* Maadid (photo credit: Garbati Pegna)

Where farmers or cooperatives do not benefit from externally supported infrastructures, fruits are packed *in situ* in large boxes or bags and sold in the local market or directly to traders. The vast majority (close to 90 %) of Moroccan dates are sold in wooden boxes of 2 or 5 kg. These containers inherently decrease the value of the dates they hold, as the rough wood sides and bottom of the box easily damage delicate date skins, which increases the date's susceptibility to microbial growth and facilitates spoilage.

In presence of an adequate infrastructure, to ensure a good quality product, dates are washed and heat-treated to kill any bacteria or insect forms that could decrease their market value and shelf life. Packing, especially in smaller boxes (250g - 500g), though requires more work and investments, preserves the quality of dates by reducing compaction and allows retailers to sell smaller quantities at higher prices. Fruits are packaged in small size boxes only by some cooperative that is provided with a processing facility.

Processing is done at household level though several cooperatives have started setting up small processing plants encouraged by external sustain programs. However, the premises where processing takes place allow to produce only for the local market failing to match the hygienic standards needed for international markets which includes the touristic hospitality business.

The processed products are: syrup, paste, jam, vinegar, coffee and flour as shown in Fig. 16 and 17. Jam and Syrup are usually the most relevant product, but the majority are made to order according to the demand of the buyers, so the quantities can vary widely. The varieties used for processing are mainly *Khalt*, but also low quality *Bou-Feggous* and other more valuable varieties and even *Mejhoul*.

Fig. 16: Date based products of cooperative Wahadi of Aoufous (Photo credit: Bartolini)

Fig. 17: Date based products of cooperative Zrigat of Aoufous (Photo credit: Bartolini)

The process for each product can vary slightly according to the level of organization of each cooperative, but in general it follows the same procedures:

- Date syrup, locally called thalaut is done in slightly different ways by different cooperatives: in some cases, in the first phase dates are by washed and drenched in water (1:1) for the night and successively heated until boiling. In other cases, they are boiled directly for 1–1.5 h depending on how dry they are. In the second phase dates are filtered and pressed in strong double layer plastic fine mesh bags and the juice concentrated for 6-7 h. Date syrup has variable characteristics depending on the kind of dates that is used, which influence the color and the density of the final product. The reference regulations are derived from some Arab Countries;
- Date paste is done with the use of meat mincers with dates destoned by hand, steam disinfected and successively slightly dried. The paste is pressed in small package, eaten as snack by local people. In some cases, it is transformed in a spread or sold in form of candy on the local market;
- Date jam is done by boiling dates in water (1:1), mechanically pulping them and concentrating, in some cases with the addition of sugar, pectin and citric acid. Bottling is done immediately and pots sterilized under pressure in autoclave;
- Date vinegar;
- Date coffee is done by roasting the seeds in a cooking pan or in an electric oven (there is no specific protocol about time and temperature). Roasted seeds are then grinded to powder, which can be aromatized or not, according to the request of the buyer;
- Date flour is done by cleaning, destoning and drying fruits in an electric oven. Dried fruits are then grinded using a common food processor. Flour is used in the local cuisine, for preparing porridge, and cake.

The machinery available can vary, although all cooperatives own a similar stock of machines and tool made of inox steel, derived from donation from NGO and governmental institution in order to improve the health standard of the products. The machine stock includes:

- Electric oven/drier;
- Electric autoclave;
- Electric destoning;
- Electric meatgrinder;
- Electric food processor;
- Manual food mill;
- Manual press;

- Manual/electric Packaging/labelling machine.

Dates are rarely stored by farmers who lack of appropriate facilities and hence have to sell the production at harvest time. Date storage needs space, protection and temperature and humidity management so even for cooperatives it is difficult to afford setting up these fundamental structures. Temperature should not pass 18 °C for short time storage though for soft and semi-dry dates 4 °C is considered the maximum acceptable temperature; for long time storage of high quality dates temperatures must be kept below -18 °C.

Recently public aid programs addressed this problem and supported the setting up of storage units. The larger facilities, with a storage capacity of about 400 t, are set up and managed by local GIEs and some have also basic processing and packaging equipment, such as fumigation and rehydration chambers, selection lines and packaging tables. Smaller storage installations are owned by cooperatives, often thanks to external support. These are refrigerated rooms with a variable storage capacity, between 40-100 t. They are often constituted by isolated prefab structures built of polyurethane sandwich panels, protected by a shelter but isolated and exposed to external environment on 5 sides.

7.1.1.3 Economical characteristics

A complete and exhaustive economic analysis resulted impossible to carry on, due to the limited information provided by the people interviewed. In the present chapter are listed the most relevant data we collected during the field survey in February 2017.

Date price can vary widely according to the variety, the type of packaging, the type of selling agreement and its timing, as shown in table 16. Processed products have a more standardize price range, as shown in table 17.

Table 16: Prices of the main date varieties according to the interviews

Variety	Price Dh/kg
Mejhoul (quality A)	150
Mejhoul (quality B)	120
Bou-Feggous (quality A)	70
Bou-Feggous (quality B)	25-50
Bou-Slikhène	40
Khalt	3-25

Table 17: Prices of the main date products according to the interviews

Product	Price

Syrup	30-45 Dh/l
Paste	25-50 Dh/kg
Jam	25-50 Dh/kg
Vinegar	50 Dh/l
Coffee	50-100 Dh/kg
Flour	30-100 Dh/kg

The access to the market represents a serious problem for many small producers and small cooperatives, unable to establish durable agreement with the organized large-scale distribution. This is especially true for remote rural locations, where the road network is inadequate and the connection with important marketplace is limited. This problem affects even heavier women, that have more problems in moving outside their villages, due to the fact that travel for trading is a task traditionally associates to men. As consequence, the majority of small producers and small cooperatives sell its entire production on local markets, where the gain is low.

In order to improve the access to the market, some form of external support is needed. Many producers rely on occasional fairs such as the various *Salons produits terroir* that are periodically organized for local products though this is a costly form of commerce. Some organizations such as Slow Food are encouraging the sale in hotels and along the touristic routes but the lack of sanitary certifications hinders the development of this market. *Plan Maroc Vert* and Slow Food have also provided some form of support to the creation of the e-commerce platform *Maroc Taswiq* that allows cooperatives to reach the markets of Agadir, Rabat and Casablanca.

Date cultivation produces a series of byproducts, traditionally absorbed by the household and livestock management, although after the introduction of modern building material, gas and electricity, the traditional cycle was broken, negatively affecting the entire palm management. Pruned leaves are used as kitchen fuel, but nowadays are mostly burned on place, if pruned at all. There has been an attempt to produce pellets or briquettes but is turned out to be not economically sustainable, needing more energy than it can provide. Fronds could be chopped and used for making compost (mixing chopped leafs with straw and manure and watering and mixing periodically for 3 months) or incorporated into the soil but there is a persistent fear they are still hosting *Bayoud* (even if the process develops a considerable amount of heat), so each farmer keeps its own compost and there is no real market for this product. Flower stems are sometimes used for artisanal handwork with limited success. Actually, the only real purposes of date byproducts are to use leaves for building fences to fight advancing of sand dunes and to use unmarketable dates as fodder for livestock.

Olive trees can be very productive: up to 100 kg/plant if properly managed, 30-35 kg/plant if not tended. Olive oil costs about 60 Dh/l, but as stated previously the majority of small producers cultivates olive mainly for self-consumption. One major problem of olives is the time needed for manual harvesting that causes long times of storage of the product before processing.

Honey is a valuable product of palm groves and is considered to have medicinal properties by locals. The environment is not favorable for bees which suffer from cold, heat and food and water scarcity, hence pure honey form date palm groves can cost up to 500 Dh/l, as stated (fonte: intervista a cooperative di Rissani)

A potential source of additional income is the collection of palm shoots. A large shoot of 8-10 kg of a valuable variety can be sold at 50 Dh and collecting it takes less than 30 min if the palm is clean. However, shoots of uncertain origins can carry *Bayoud*, and many producers prefer to use micro-propagate plantlets, provided by commercial nurseries or by INRA.

Labor force cost about 100 Dh/day, although the cost can be higher for specialized workers. In general, labor is scarce, specially concerning young people and during harvesting season.

The average cost for renting tractor and toothed cultivators for land is about 120-150 Dh/hour.

7.2 Diagnosis

Oases palm groves, because of their complex organization and varietal mix, where palms that give fruits of very little value are predominant, seem to be no longer interesting for many owners on an economic point of view and the consequence is neglecting them or moving to an opportunistic farming system, where the minimum work is done and only the easiest palms are harvested. This situation is worsened by the many alternatives offered by development, access to means of travelling and globalization. However, oasis still constitute an important and reliable resource thanks to the heritage of investments done in centuries by generations of farmers and to the presence of high biodiversity and variety of genetic resources. This makes them a national heritage on a cultural and ecological point of view and a strategical resource from where germplasm can be drawn in case of necessity.

7.2.1 Main problems of oases production system.

The major causes of insufficient productivity in the Moroccan agricultural sector have been highlighted by various analyses carried out in the past years:

- Degradation of natural resources;
- Rural poverty;
- Insufficient social infrastructure;
- Limited involvement of the rural population, especially women, in the development process;
- Poor use of the Government's human and financial resources;
- Virtual absence of rural financial services for small farmers and the rural poor

These critical issues are all present in the oasis farming system and often made worse by its' intrinsic characteristics.

Dates are no longer an important staple food for nomads and oasis dwellers, substituted by other more varied and complete foods, easy to find at affordable cost. Nowadays dates are consumed in lower quantities, mostly in special occasions, hence request for quality has increased and this has lowered the value of most *khalt* dates produced in the old traditional groves. Even the better ones suffer the competition of those produced in the new modern plantations or coming from abroad which are generally more appealing and better marketed.

Moreover, farmers are aging, while youths are reluctant to take over and prefer to search elsewhere for easier perspectives, while the grove progressively perishes and recovering gets more and more difficult. This is especially true in the most developed areas with connection to cities and tourism, while is less evident in more insulated oases, though it could extend also to these areas.

Fragmentation of property is another constraint, since it makes it difficult for many owners to earn a living on agriculture; many of them just have somebody to look after their property and settle with what they bring or are part time farmers, while others rent their parcels to other farmers. In some cases cooperatives are formed and rent land from different owners for a period of at least 7 years, but in this case only the best plots are chosen. In spite of this sad situation, cooperation among farmers is not easy to establish and FIMADATTES reported cases in which even international funded interventions failed due to disagreement among the owners.

National strategies for sustaining oases and date palm cultivation can address only partially farmers most specific needs due to the economic characteristics of the latter.

7.2.2 Main problems of date palm chain production.

According to INRA swot analysis (Chetto *et al*., 2005), date production can contribute to the Moroccan Development strategy on different levels. In relation to national consumption, date production is sufficiently sustainable and competitive from an economic point of view, but shows some problems in the production chain, especially in the processing and marketing phases. Each intervention aimed at improving market potential can positively affect rural development.

Strengths:

- Good date varieties present in Morocco. This allows meeting consumers' request and setting up of different production chains (fresh fruits and processed products);
- Traditional operations grant a high flexibility, especially for marketing organization, since the production volume of fresh and transformed product can easily be modulated according to the market demands.

Weaknesses:

- Cooperative system involves only a small part of date producers, hence the sector is still poorly organized.
- Prevalence of informal relations between producers and traders;
- Management deficiencies for production costs and taxation.

Opportunities:

- Good local consumption assures the local market sustainability;
- Good knowhow about date production by Moroccan Agricultural Research;
- Understanding of the importance of marketing improvement by producers;
- Progressive improvement of production chain grants increasing product value;
- Increasing interest of the consumers for a product of higher quality and properly managed;
- Local institution with expertise in agricultural product processing and marketing can sustain the date producers.

Threats:

- Poor infrastructure for processing and storage;
- Moroccan date is not well-known, and local consumers often prefer imported products;
- Moroccan consumption is concentrated in occasion of religious and familiar events, not matching the local availability period.

On a technical point of view, the main constraints affecting plm groves and causing their deterioration are resumed in table 18.

Table 18: Major problems affecting date palm cultivation in traditional groves and their causes and consequences

Problem	**Causes**	**Consequence**
Advancing sand dunes	Climate change, cost and scarcity of labor, cost of mechanization, water scarcity.	Loss of surface, loss of product, loss of asset
Deterioration of irrigation systems	Poor maintenance	Waste of water, inefficient irrigation.
Cost of operations	Inefficiencies, cost of labour, cost of inputs	Neglecting some operations
Insufficient investments	Low profitability of the system	Deterioration of asset, decrease of production and product value
Diseases	Intrinsic, poor attention in farming operations, absence of treating.	Death of palms, loss of value of shoots, need for labor for treatment or elimination
Palm height	Age, variety, lack of renewing.	Neglecting tending operations and harvest.
Neglecting tending operations*	Palm height, cost and scarcity of labor	Reduced production, reduced quality
Failure to exploit offshoots potentialities	Cost and scarcity of labor,	Weakening of palms, difficulties accessing palms
Water scarcity and low water quality	Overexploiting, deepening of water table, inefficient irrigation system	Death of palms, reduced production, reduced quality

Failure to exploit production potentialities	Low value of fruits, difficulties to access fruits for harvesting, cost and scarcity of labor	Waste of potentialities, spreading of pests and diseases.
Low value of fruits	Low value varieties, poor tending practices, poor harvesting technique, poor post-harvest management**	Low profitability of the system, discouraging of investments

* Improving pollination practice and technique is seen as a major need

** GIEs provide to farmers the possibility of better marketing their products but many don't take advantage of this opportunity, mainly claiming that they won't get back the same amount (weight) of product they have given in. This is because stored dates undergo various changings, mostly negative, such as loss of weight, skin detachment and crystallization of sugars.

8 PROPOSAL

8.1 Assets and possibilities for the oasis economy

Many actions have been suggested and in some cases implemented, for sustaining the traditional farming system in the oasis environment. However, the fact of the matter is that conventional cultivation practices are time-taking, tiring, discourage young people from taking up their parents' job and that many of the dates from the existing groves are of poor market value. So traditional groves continue to be progressively abandoned or poorly tended, where the owners reduce to a minimum cultivation and just settle for what the plants naturally produce.

Stopping or inverting this trend needs effective actions, based on addressing the weaknesses that have been pointed out and on exploiting the strengths that anyway exist. Concerning the latter point it should be noted that in the old groves there is an important existing asset with no need for capital amortization and that, in most cases, still has potentialities for further exploiting. Four main objectives for reinvigorating this system can be envisaged:

- Raising the economic and technical efficiency of the system
- Improving product quality
- Valorization of the oasis produce

- Increasing farm work attractiveness

The first three objectives aim at making oasis farming profitable while the fourth one aims at addressing the unwillingness of farmers and youths to undertake this kind of work.

It is quite impossible to match the same efficiency of a modern, intensive and specialized plantation in a traditional grove but, in most cases, there is extensive room for improvement. Currently, the palms are poorly attended and consequently weakened and prone to diseases and parasitic attacks, while productivity is low in quality and quantity; moreover, the harvesting operation, which in some cases is the only one that farmers carry out, is hindered, difficult and time tacking. Obviously, the intensification of tending operations generates higher costs and need for skilled labor. From an economic point of view, there is need for investments that can be repaid by an increased revenue, while from a technical point of view there is need for technology that can increase work productivity and make easier to carry out some of the most important farming operations.

The second objective aims at taking advantage of an existing capital which is immediately available and at low cost. The main products that can be harvested are dates and off-shoots. Dates have different value according to variety, size and conditions, with *Mejhoul* dates being, at the present, the most valuable and the *Khalt* the least. Within a variety the quality is tied to the intrinsic and extrinsic characteristics of the plant, where the latter can be influenced by the farming technique together with the product quantity. Concerning the *Khalt* varieties their low value does not apparently justify time and capital investments, however their nutritional properties and the sugar content, together with the large amounts available, should be exploited, at last for industrial use. It would be hence advisable to take good care of the valuable plants and at the same time keep clean and accessible the *khalt* palms in order to allow a good production and make harvesting easy and efficient; setting up large capacity industrial processing facilities for dates and byproducts should also be encouraged in order to exploit *khalt* potentialities. Concerning off-shoots, those of good varieties have a high value on the local and national market and constitute a source of revenue, but their removal with the use of manual tools requires time and moreover they are in some cases suspected to be infected with *Bayoud* so often they are not collected and the possible earning is lost. Another consequence of not collecting off-shoots is the weakening of the palm and its development into a bushy structure, where access to the main plant and to the surrounding soil is hindered. Another resource available in the groves is the abundant biomass constituted by the palm leafs that can be used as fuel or fodder component, when duly processed, though the most interesting and sustainable

use is that of grinding and composting into green manure, a precious input for the often depleted oasis soils.

Agricultural work is often hard and tedious and requires physical effort for carrying out the different operations and for operating in an uncomfortable environment. All this, together with the low return, makes it harsh for the elders and discouraging for the youngest. In addition, most operations need particular skills and acquaintance with the modern and most effective techniques that are not widespread in the traditional and aged agricultural environment. In this context engaging specialized labor, specifically trained and equipped with functional tools, could overcome most of the mentioned the constraints.

8.2 Mechanizing farm operations in oasis farming system

Mechanization is commonly seen as linked to modern and intensive agriculture on large land extension, while in most industrialized countries small motorized equipment has made possible for thousands of smallholder farmers to gradually move out from manual or animal powered work, increasing labor productivity and reducing fatigue. We think that also in traditional oasis farming system the introduction of small mechanization could represent a key action for addressing some of the main constraints previously examined.

Small mechanization includes a selection of different power units and implements of small size and reduced cost that can be used for almost all farming operations, in the same way as larger equipment. Small mechanization can provide considerable help to smallholder farmers by boosting, in some cases up to 50 times, their productivity. In the oasis system, small mechanization appears to be an appropriate and sustainable solution (FAO, 2017c), since it is not complex to master, it doesn't require high investments and running costs, and it has the physical characteristics for working in a tight and rough environment.

It could seem a controversial option to propose modernization through mechanization in a traditional context, such as an old palm grove in a desert oasis, but the use of motorized tools could allow to better perform the normal operations, yet recovering and maintaining the original framework.

In the situation described in the previous chapters, the complete or partial mechanization of several possible operations can represent an important factor for the management of oasis agro-

ecosystem. It can provide a new incitement and make field work more attractive for young people, thus valorizing their role, enhancing labor productivity and skills, and reducing fatigue considerably. Especially for aerial operation, where is required to climb up the palms, the use of motorized lifting devices would also have a great impact on workers' safety, besides fostering the execution of the other important operations that are carried out at the bud level. Mechanization of post-harvest and processing phases can also increase women engagement in date production chain and should be subsequently taken into account.

In modern agriculture mechanization has allowed to increase noticeably work outputs, reducing drudgery and, when correctly applied, protecting worker's health and increasing safety. However, one of the main limitations of mechanization remains the relatively high investment costs and the need for scale economy, which makes it difficult to access by many farmers and particularly by smallholders.

Increased power availability for farm work often has some positive effect on productivity but its efficiency, and consequently its convenience, can be dramatically undermined by wrong or inappropriate choices that lead to poor agronomic results and higher costs due to underutilization, increased energy needs, premature wear-out and breakages. For these reasons, mechanization interventions should be carefully designed, taking in account adequacy, appropriateness of technological level, correct sizing, local infrastructure and, in case the action proceeds from outside, its acceptability by the farmers and their willingness to change the usual system. Adequate specific training is essential in both cases.

8.3 Possible mechanization package for the oasis farming system

Introducing mechanization in Moroccan oasis is technically and technologically possible, though specific tools for palm cultivation do not really exist and when mechanization is used, tools are mostly derived from other sectors. However, all stakeholders are acquainted with agricultural mechanization, being present in other well-known farming systems and tools exist for each one of the operations that date palm needs.

In the case of Moroccan oasis farming system, as previously described, the most suitable mechanizing intervention appears to be the one based on small mechanization, which means low power equipment in the range of about 0.15-15 kW, such as 2-wheel tractors (motocultivators), motorhoes and motocultivator-linked trailers. These machines are capable of operating nimbly inside

small plots with ditches, scattered palms and other tree crops or obstacles, performing the essential operations needed for rehabilitation and cultivation of palm groves, such as tillage and transport together with other important ones like ditching and mulching (see Fig. 18). They are simple to use and maintain and share some similarity with tools and operations for animal traction that is still widespread in this environment. Small mechanization also includes specialized equipment of small dimension, such as dumpers and excavators, mounted equipment like sprayers and platforms (Bonechi et al., 2018), and various tools (shears, chisels, chainsaws, shakers etc.) driven directly or indirectly (by electricity or compressed air) by the engine of the main machine.

Fig. 18: Demonstration of weeding within an irrigation basin with a motocultivator (Photo credit: Garbati Pegna)

Following these considerations, a proposal for mechanizing farming operations in traditional palm groves has been drafted and is reported in table 18, where the machines that could be used for each date palm cultivating operation are listed. All this equipment already exists on the agricultural machinery market, though in some cases some adaptation and experimentation would be advisable. It is a low power light equipment, capable of moving in tight space and under low canopies and performing all the operations done by larger and more expensive machines, though in smaller scale.

Table 18: Possible mechanization scheme

Operation	Machine/equipment
Earth moving (removal of sand)	Compact self-propelled excavator with bucket Compact skid steer loader Compact tractor with trailer Motocultivator with trailer Compact transporter
Collection of shoots	Compact self-propelled excavator with bucket or chisel Compact tractor with mounted backhoe with special bucket or chisel
Plantation	Compact excavator Compact tractor with mounted backhoe with bucket Compact tractor with mounted post hole digger
Tillage	Compact tractor with plow/rotary hoe Motocultivator with plow/rotary plow/rotary hoe Motorhoe
Digging of furrows and channels	Compact tractor ditcher/rotary ditcher Compact self-propelled excavator with bucket or special bucket Motocultivator with ditcher/rotary plough
Pruning (i.e. cutting of leafs and other vegetative parts)	Compact self-propelled off-road aerial platform Metal ladder (adapted to date palm) or mobile scaffolding Power scissors (pneumatic or electric) Chain saw (pneumatic, electric, heat engine) Motorized static mulcher/shredder Motocultivator with flail mower or static mulcher
Cleaning of the trunk	Power chisel (pneumatic or electric) Compact self-propelled excavator with cutter head
Fertilizing	Compact tractor with mounted spreader (broadcaster/localizer) Motocultivator with spreader
Dethorning	Compact self-propelled off-road aerial platform Metal ladder (adapted to date palm) or mobile scaffolding Power scissors (pneumatic or electric)
Collection of pollen	Compact self-propelled off-road aerial platform Metal ladder (adapted to date palm) or mobile scaffolding Power scissors (pneumatic or electric)
Pollination	Compact self-propelled off-road aerial platform

	Metal ladder (adapted to date palm) or mobile scaffolding Pollen blower (pneumatic or electric)
Pest control	Compact tractor with mounted sprayer Motocultivator with trailed sprayer Compact transporter with sprayer Knapsack motorized sprayer
Weed control	Motocultivator with trailed sprayer Compact transporter with sprayer Knapsack motorized sprayer Motocultivator with flail mower or vertical axle mower
Bunch thinning	Compact self-propelled off-road aerial platform Metal ladder (adapted to date palm) or mobile scaffolding
Arranging of fronds and bunches	Compact self-propelled off-road aerial platform Metal ladder (adapted to date palm) or mobile scaffolding
Bunch bagging	Compact self-propelled off-road aerial platform Metal ladder (adapted to date palm) or mobile scaffolding
Harvesting	Compact self-propelled off-road aerial platform Metal ladder (adapted to date palm) or mobile scaffolding
Transport	Compact tractor with trailer Motocultivator with trailer Compact transporter

Setting up a pilot unit with some or all of the equipment listed in table 18 could allow to better evaluate the effects of introducing small mechanization in Moroccan oases traditional farming system. Two or three of these units could be tested in different areas, in order to evaluate benefits and constraints together with the technical and economic feasibility.

Concerning the last two aspects it is possible to envisage that the cost and the working capacity of a set of motorized machines, even if composed by light equipment, would be rentable only when an area of about 2-20 ha is available, depending on the composition of the unit. Table 19 shows an example of typical cost and working capacity of a motocultivator, a trailer and a small self-moved platform (see Fig. 19).

Table 19 – Characteristics and costs of some machines suitable for use in traditional palm groves (source: analysis of Italian market carried out by the authors in 2016)

Type	Power	Operation	Work characteristics	Cost
Two-wheel tractor	10-12 kW	rotary tillage	working capacity ~ 50-100 m^2/h	~ 5,000 Eur
Trailer*	-	transport	payload≒ 400 kg, speed≒ 5 km/h	~ 2,000 Eur
Self-moving platform	9 kW	access to palm crown level for 1 operator	time for positioning and lifting: ~ 260 s**	~ 35,000 Eur

* Driving wheels trailer (needs to be linked to a motocultivator)

** Bonechi et al, 2018

Fig. 19: Light off-road platform for easy access to higher palms in traditional palm groves (Photo credit: Garbati Pegna)

Though at the present day electric 2-wheel and small 4-wheel tractors are still in an experimental stage, some of the proposed motorized tools and implements are already available also in an electrically driven version, so a possible option for partially reducing running costs is that of utilizing solar energy, which is abundantly available in the oasis areas of Morocco, e.g. by setting up small photovoltaic charging stations.

As stated in the previous chapters, the average property is quite small, in the range of 0.4-0.5 ha, and cannot sustain neither the purchase nor the management of a complete set of equipment. It should be managed by an organized farmers' cooperative or by an independent contractor.

Farmers' cooperatives already exist in almost all Moroccan oases, but the limitation of this form of management lies in the lack of specific skills by the users of the equipment, which in some cases needs specialized or at least expert operators: this may lead to misuse and poor maintenance of the equipment. An independent contractor, e.g. a service company or cooperative, could be more capable of properly managing the set and could operate in a wider area than a farmers' cooperative, and it is hence preferable. The activity of this contractor should include the initial palm groves rehabilitation, through restoring and renovating of the watering system, clearing of the parcels, removal of off-shoots and pruning of leaves, in addition to all the best practice operations that have been previously described. In both cases the investment could be better amortized by using the equipment also for different cultivations and even in other fields, such as the building sector, when not needed for the date palm cultivation. Even if not completely rentable, the investment would be justified by the strategic importance of maintaining vital the oasis farming system and could benefit of external financial support.

In any case a deeper economic analysis would provide more clear figures on the mechanization option and on the possible composition of the pilot unit, whose test scheme should be carefully designed involving private and public local stakeholders. Other issues that should be taken into account when planning a mechanization intervention are those of the layout of the grove and of the property of the parcels. As in any other agricultural system where mechanization is used, not only the equipment must be specifically designed for the crop, but also the cultivation has to be adapted for the best use of the machines. In our case some adjustments would be needed to make the access to the parcels and to the palms easier and the other cropping operations more efficient. Also the land tenure would in most cases need to be rearranged through cooperation between landlord, exchanges and rental options. In the case of testing the pilot units a simple option would be that of renting a suitable extent of land by the entity in charge of managing the unit.

Examples of external provision of agricultural mechanization inputs for smallholders:

- Globalization and easiness of communication have reached even an usually backward and traditional environment such as the agricultural one and even smallholders of the poorest and more insulated areas can keep updated through i.t. tools such as smartphones and the use of

internet. For this reason, many new kinds of support are now available for farmers, especially for the youngest and more dynamic ones.

- In Nigeria small farmers can access GPS equipped tractors for rent through a system similar to that of car-sharing, with the difference that tractors are owned by individuals and not by a unique company and the technology startup, called *Hello Tractor*, only sells the tractors and provides the application for managing of the system (Chatel, 2017). In 2016, *Hello Tractor* had sold 1,000 tractors in Nigeria and its' activity is further expanding with the support of the USAID though the fact that they are providing a 15 HP tractor at a price of 3,700 EUR makes you wonder about the reliability of the proposed power unit.
- In India, the start-up Trringo proposes an Uber-type service for connecting independent tractor owners to small farmers. *Trringo*'s mobile app puts them in touch and at the end of the job the hiree farmer can appraise the tractor owner (Chatel, 2017).
- Other examples of using i.t. technology for smallholder farm mechanization and borrowing successful ideas from more advanced sectors are Rent to Own in Zambia and WeFarmUp in West Africa. The former is an NGO that leases equipment packaged with various services (financial, training, and delivery) while the latter is an Airbnb style agricultural equipment platform that enables farmers to share their equipment (Chatel, 2017).

These examples show how the main constraints of agricultural mechanization, that are investment cost and farmers' capability to manage it, can be addressed in many different ways and that solutions are arising at a similar rate of other more advanced sectors which allows to predict that mechanization will be in the near future an essential and unavoidable asset even for smallest farmers, though a thoughtful and sound design will still be needed in order to address easy enthusiasms and naïve approaches that may lead to still possible failures.

9 CONCLUSIONS

Enhancing date production appears to be one of the possible actions for sustaining oasis economy and many public projects are aiming at this objective: the crucial point is of course encouraging farmers' engagement and the valorization of the oasis products and quality improvement is a direct consequence of well conducted tending operations.

Sustaining farmers' date production through small mechanization seems possible because of the need to reduce work burden and increase labor productivity; most of the farming operations can

be mechanized, deriving machines and tools from similar operations done for other crops, with or without adaptations and a practical intervention can be designed by defining a pilot package and all the corollary actions needed for its successful application to be replicated and entrusted to selected specialized organizations in different areas, in order to evaluate its advantages and possible problems. This kind of action would support the implementation of the governmental strategies as well as other interventions (e.g., of the international cooperation agencies), allowing to create a network of practice and to build new partnerships.

The proposed equipment seems to respond to the requisites but should be object of a deeper analysis, in coordination with private and public stakeholders, in order to evaluate costs, performances, acceptability and overall suitability for the task. This analysis should be carried out through pilot units to be implemented in a few oases, representing the general situation. An effective and efficient way of management should also be defined, possibly involving specialized service entities such as mechanization contractors, cooperatives or NGOs for providing technical assistance in farmer cooperative development and capacity building, suitable land use pattern and linkages to appropriate markets.

As a matter of fact, introducing mechanization may reduce drudgery, encourage youths and increase labor productivity and safety, but economic benefits of mechanizing traditional palm groves are yet to be proved. Any intervention of this kind should be economically and technically sustainable and adequate in the environment where it is proposed however, the importance of preserving this environment as a cultural heritage and a reserve of date palm genetic material allows to imagine an externally support (subsidies) in case sustainability is not achievable.

10 REFERENCES

Agence pour la Promotion et le Développement Economique et Social des Provinces du Sud du Royaume. 2015. Programme Oasis Sud: Une expérience marocaine de développement durable

APP – Agency of Partnership for progress. 201?. Invest in Morocco date post-harvest handling and packaging activities - Improving Quality and Marketability in the Date Sector.

ANDZOA (a). Accessed 12/05/2017. <http://andzoa.ma/fr/andzoa/zone-dintervention/zone-oasienne/donnees-generales/liste-des-communes-de-la-zone-oasienne-2/>

ANDZOA (b). Accessed 12/05/2017. <http://andzoa.ma/fr/andzoa/zone-dintervention/zone-oasienne/reserve-de-biosphere-des-oasis-du-sud-du-maroc/>

ANDZOA (c). Accessed 15/05/2017. <http://andzoa.ma/wp-content/uploads/2016/11/plaquette-EN.pdf>

Aouatif Chapron H. 2015. Analyse de la chaîne de valeur datte Jihel. Province de Zagora. Programme PEDEL / GIZ. Morocco

Bendiab K., Baaziz M., Majourhat K. 2008. Preliminary date palm cultivar composition of Moroccan palm groves as revealed by leaf isoenzyme phenotypes; Biochemical Systematics and Ecology, 26; 71-82

Ben Salah M. 2014. Le recyclage des sus-produits des oasis: acquis et prespectives. OSS MENA_DELP, Tunisie.

Berkat O., Tazi, M. 2004. Morocco Country Pasture/Forage Resource Profiles; FAO, Rome. Accessed 27/12/2017. <http://www.fao.org/ag/AGP/AGPC/doc/Counprof/Morocco/morocco.htm#2>

Bonechi F., Garbati Pegna F., Bonaiuti E. 2018. Performance Evaluation of an Off-road Light Aerial Platform for Date Palm Cultivation; Proceedings of the 6th International date palm Conference, Abu Dhabi (UAE), March, 19-22, 2018.

Boulanouar B., Kradi C. 2005. Actes du symposium international sur: le developpement durable des systemes oasiens. INRA, Morocco

CEDTOD. Accessed 12/03/2018. <https://www.facebook.com/people/Centre-dEtudes-Oasiennes-Cedtod-jorf/100009034552479?hc_ref=ARSiRGil_1YR7vPWNr279EJNZhKlVchgDMpq80eZJ7ZYXdDYVlFPyAaCFE1sKpRqAPY>

Chambre d'Agriculture de la Région Drâa-Tafilalet. 2017. Rapport d'Activites – Première Edition du Salon Régional des Produits du Terroir

Chatel B. 2017. Dossier Agricultural mechanization: Agricultural mechanization in progress. Spore-CTA. Accessed 10/6/2017. <http://spore.cta.int/en/dossiers/article/agricultural-mechanisation-in-progress.html>

Chetto A., Harrak H., El Hachami N. 2005. Le Marketing Des Dattes Au Maroc, Défaillances, Préférences et Attentes ; INRA, Morocco.

Dahan R., Boughlala M., Mrabet R., Laamari A., Balaghi R., Lajouad B. 2012. A Review of Available Knowledge on Land Degradation in Morocco, Oasis Country report 2, ICARDA (International Center for Agricultural Research in the Dry Areas).

De Haas H. 2001. Migration and Agricultural Transformations in the oases of Morocco and Tunisia; Utrecht: KNAG.

De Haas H. 1998. Socio-Economic Transformations and Oasis Agriculture in Southern Morocco. L. de Haan and P. Blaikie eds., Looking at Maps in the Dark: Directions for Geographical Research in Land Management and Sustainable Development in Rural and Urban Environments of the Third World. Utrecht/Amsterdam : KNAG/FRW UvA, 65-78.

ENABEL. Accessed 26/02/2018. <https://www.enabel.be/content/enabel-morocco>

European Commission (EC). (2013). Avenant n° 1 a la Convention de Financement n° ENPI/2010/022-590 “Programme d'Appui à la Politique Sectorielle Agricole du Maroc (PAPSA)". Annexe II "Dispositions Techniques et Administratives" de la convention de financement

Ezilon maps. Accessed 29/1/2018. <https://www.ezilon.com/maps/africa/morocco-physical-maps.html>

FAO (a). Accessed 27/12/2017. Globally Important Agricultural Heritage Systems (GIAHS); <http://www.fao.org/giahs/en/>

FAO (b). 2017. Moroccan oasis in the agricultural World Heritage; accessed 31/01/18; <http://www.fao.org/fileadmin/user_upload/FAO-countries/Maroc/docs/2017-Oasis-FAO-EN.pdf>

FAO (c). Accessed 2/6/2017. Sustainable agricultural mechanization; <http://www.fao.org/sustainable-agricultural-mechanization/overview/what-is-sustainable-mechanization/en/>

Fratucello C. 2015. Gli agroecosistemi della Valle d’Aoufous e della Plaine del Tafilalet. Potenzialità e criticità dei sistemi produttivi e delle politiche di sviluppo rurale nelle oasi di Errachidia. University of Turin, Italy.

Haddouch M. 1993. Situation actuelle et perspectives de développement du palmier dattier au Maroc. In: Ferry M. (ed.), Greiner D. (ed.). Le palmier dattier dans l'agriculture d'oasis des pays méditerranéens. Zaragoza: CIHEAM. p. 63-79 (Option s Méditerranéennes: Série A. Séminaires Méditerranéens; n. 28).

INRA. 2011. Atlas du Palmier Dattier au Maroc.

Kradi C. 2012. L’agriculture solidaire dans les éco-systèmes fragiles au Maroc. INRA, Morocco.

Kradi C., Andriamaninty F., Djeddou R., Nait Merzoug S., Nguyen Van T., Ait Hmida A. 2002. Analyse des systemes de production oasiens et des strategies des agriculteurs dans la province d'Errachidia, Maroc. ICRA, ORMVAT, INRA/CRRA, Morocco

LabOasis Foundation. Accessed 04/03/2018. <http://www.laboasis.org/it/>

Maroc Taswiq. Accesses 18/02/2018. <http://www.maroctaswiq.com/>

MCC. Accessed 18/02/2018. <https://www.mcc.gov/where-we-work/program/morocco-compact>

Medias24. Accessed 29/01/2018. <https://www.medias24.com/DOCUMENTS.html>

Ministere de l'Agriculture, de la Pêches Maritimes, du Développement Rural et des Eaux et Forêts (a). Accessed 19/02/2018. <http://www.agriculture.gov.ma/pages/rapports-statistiques/campagne-agricole-2015-2016>

Ministere de l'Agriculture, de la Pêches Maritimes, du Développement Rural et des Eaux et Forêts (b). Accessed 19/02/2018. <http://www.agriculture.gov.ma/en/pages/strategy>

Nations Encyclopedia. Accessed 29/01/2018. <http://www.nationsencyclopedia.com/geography/Morocco-to-Slovakia/Morocco.html#ixzz55ZeSPfsBA>

Reseau Associatif de Developpement Durable des Oasis. Accessed 06/03/2018. <http://www.raddo.org/>

Royame du Maroc. 2010. Programme de Développement Territorial Durable des Oasis du Tafilalet - Les Oasis du Tafilalet, revalorisons un territoire de vie unique à haute valeur patrimoniale.

Sghaier M. 2014. Perspectives de développement de l'approche filière pour la structuration des activités des communautés locales au niveau des oasis de la région MENA (Algérie, Egypte, Jordanie, Maroc et Tunisie). OSS MENA_DELP, Tunisie

Sedra M. H. 2003. Le Palmier Dattier base de la mise en valeur des oasis au Maroc,Techniques phoénicicoles et Création d'oasis. INRA, Morocco.

Sedra M. H. 2012. Guide du Phoeniciculteur, Mise en place et conduite des vergers phoénicicole. INRA, Morocco.

The view from Morocco. Accessed 29/01/2018. <http://theviewfrommorocco.blogspot.com/>

Toumi L. 2008. La Nouvelle Stratégie Agricole au Maroc (Plan Vert): Les Clés de la Réussite.

UN climate change conference COP22. 2016. Initiative Oasis Durables : Pour la Reconnaisance, la Préservation et le Développment solidarie des Oasis comme modèles de résilience aux Changement Climatiques. Marrakesh, Morocco.

UNESCO. Accessed 12/05/2017. <http://www.unesco.org/new/en/natural-sciences/environment/ecological-sciences/biosphere-reserves/main-characteristics/functions/>

Wikipedia Morocco. Accessed 29/01/2018. <https://en.wikipedia.org/wiki/Morocco#Geography>

Wikitravel. Accessed 12/05/2017. <http://wikitravel.org/en/Morocco>

PART 2:

RANGELAND RESTORATION IN JORDAN

Authors: Claudio Zucca [5], Pietro Bartolini [6]
Co-author: Enrico Bonaiuti [7]

[5] International Center for Agricultural Research in the Dry Areas (ICARDA), Jordan
[6] University of Florence, Department of agricultural, food and forestry systems (GESAAF), Italy
[7] International Center for Agricultural Research in the Dry Areas (ICARDA), Jordan

1 Description of restoration interventions in Jordan Badia with a stress on their weaknesses and constraints.

1.1 The Badia Region in Jordan.

The Central and West Asia and North Africa (CWANA) region encompasses large areas of arid and semi-arid zones. These are areas where rainfall, relative to the level of evapotranspiration, is inadequate to sustain reliable crop production. Most of the arid and semi-arid zones of the CWANA region are rangelands and are characterized by wide variability in rainfall and temperature, and frequent droughts.

The so called *Badia* region of Jordan is characterized by arid rangelands and deserts which cover about 80% of the country area and extend to the south and to east in continuity with the Saudi and Iraqi steppes and deserts, as shown by the figure below. It is characterized by hot-dry summers and cold-dry winters, and by an average annual rainfall of 50 to 200 mm with high inter-annual variability. It presents elevations between 700 and 1,100 meters above sea level.

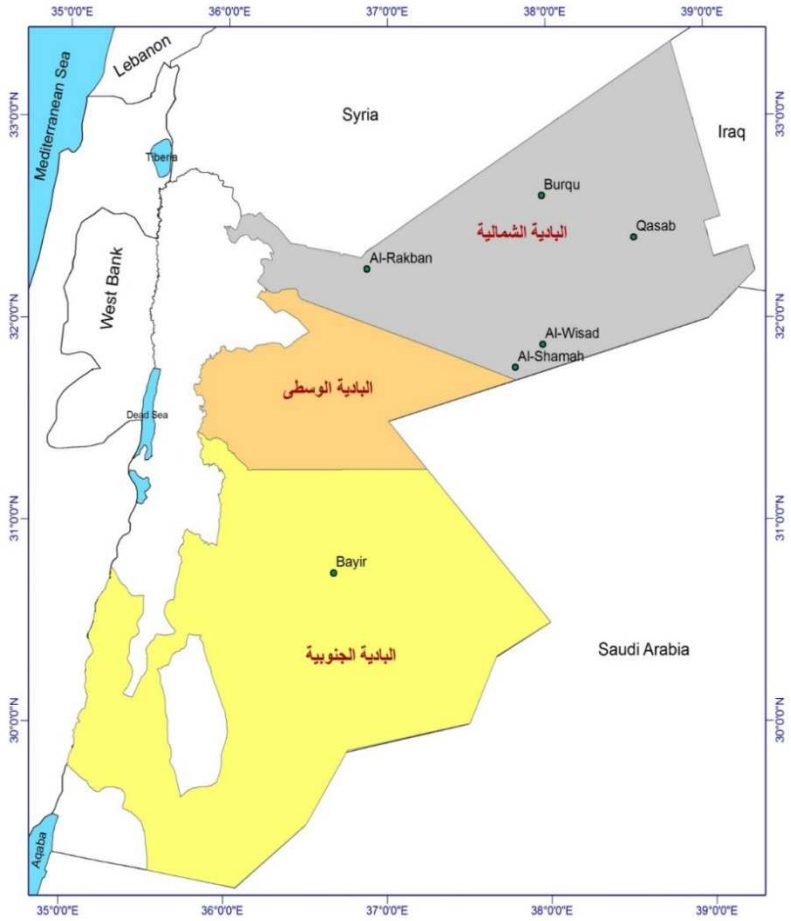

Fig. 20: The administrative boundaries of Jordan Badia (BRP 2012)

The increased demand for meat in the region has driven an increase in livestock numbers, particularly the number of sheep and goat witnessed a continuous increase since 1990. In Jordan, the 24-year average since 1990 was 2.742 million heads, fluctuating due to many events and factors that affected Jordan including the Gulf war, the devaluation of the Jordanian dinar, the waves of droughts that hit Jordan and the changes in the government policies (MOE – IUCN – GEF, 2015). This process has also led to changes in herding systems. It is estimated that only 2% of livestock herders in Jordan Badia are still nomadic, and that 80% of them own a truck, tractor, or car (Davies et al., 2010). Increasing cultivation (e.g., barley) by bringing into production lands from steppe and desert rangelands that may not be suited to cropping. The increase in grazing pressure and cultivation of traditional and fragile grazing lands has led to severe degradation of these resources. Consequently, the region is either affected or severely threatened by desertification (MOE, 2015). The new plan to combat desertification in Jordan (MOE, 2015) reported that the rangelands in Jordan provided over the last 24 years a sum of JD404 million in terms of direct saved costs of animal feed evaluated at the prices of 2013, and stated that continuing the current practices without any new measures/projects will result in huge economic losses that may even exceed hundreds of million dinars.

1.2 Recent rangeland restoration policies and programs and large-scale restoration interventions conducted in Jordanian Badia.

During the recent decades, national and international institutions put in action several policies and programs to restore the degraded rangelands of Jordanian Badia. Considerable investments have been made among which the recent Badia Restoration program (BRP), established in 2008, is the most important. The following two sections summarize the main ones, with particular focus on the policies (section 1.2.1) and to large-scale restoration interventions (section 1.2.2).

It has to be noted that due to the relatively limited public documentation available about the actual achievements of these programs, in many cases it was not possible to identify, not even qualitatively, the interventions actually promoted by such policies in Badia, and their impacts. Personal contacts with officers of various Ministries allowed us to find little and mainly not specific written information. One dataset provided by the Jordan valley Authority, discussed in section 1.2.2, lists interventions conducted in Badia during a relatively long period of time, but it does not link those works to the policies and programs discussed below.

1.2.1 National policies and programs relevant to rangeland degradation and restoration

Pre-National Strategy Era. Between 1950 and 1969, a series of interventions took place in Jordan, put in action by the Ministry of Agriculture and the Royal Jordanian Army. They made anti-erosion stony structures, dune fixation interventions, wells, water tanks, and other water harvesting infrastructures, some of which still visible and operational today. These interventions were not integrated in an overall strategy, but their value and quality is still recognized by local experts. This intervention phase ended in 1970.

The National Environmental Strategy (NES). The first environmental strategy in Jordan (NES) was developed in 1991, as a response to the World Conservation Strategy formulated by IUCN, UNEP and WWF in 1980 (Ministry of Planning & International Cooperation, 2017). NES catalogued all environmental problems and pressure factors and contained more than 400 specific recommendations and suggested actions in the field of environmental protection and conservation (Ministry of Agriculture, 2013). Unfortunately, the NES did not set clear priorities and Jordan regional governments allocated budget to several environmental initiatives achieving an overall limited impact. However, the NES recommendations about agriculture and land management, water resources, wildlife habitats, coastal areas and marine environment and energy, still represent a useful baseline for the development of future policies (Ministry of Planning & International Cooperation, 2017).

National Environmental Action Plan (NEAP). The NEAP was a practical environmental guidebook developed in 1995. It provided a comprehensive assessment of environmental problems and remediation opportunities in Jordan, combined with a prioritized and phased plan of action for addressing the issues. The NEAP identified 41 environmental priorities needs, focusing on a shortlist of 19, clustered in four projects:

- Development of a national land use planning/zoning system;
- Management of agricultural plastic waste;
- Preservation of forest lands;
- Urban and regional land use planning.

NEAP interventions were reported as almost entirely implemented (Ministry of Planning & International Cooperation, 2017). No information was obtained by the authors of this study on the interventions implemented in Badia.

National Agenda 21. Agenda 21 was a multi sectorial national strategy for sustainable development launched in 2000 with technical and financial support from UNDP. For combating desertification, the National Agenda 21 proposed the following strategic objectives:

- Developing a methodology for addressing and mapping the dynamics of desertification, and the processes and hazards in each ecological zone in Jordan;
- Determine priority areas;
- Diversifying the income of people to mitigate poverty and reduce pressure on land resources;
- Adopting sustainable land use plans and sustainable management of the water resources with the aid of remote sensing and GIS.

Regarding rangeland development, the following objectives were proposed:

- Increasing the productivity and improving the management of rangelands on a sustainable basis; Strengthening capacity building by setting-up appropriate training, planning and management units, a research unit and improving capacities of human resources;
- Ensuring a sustainable utilization of the forest and range resources by the design and implementation of rational management systems (Ministry of Planning & International Cooperation, 2017).

No information was obtained by the authors of this study on the interventions implemented in Badia.

National Strategy for Agricultural Development (NSAD). The NSAD was prepared by the Consultative Economic Council in 2002 for the decade 2000-2010. The strategy stressed on sustainable agriculture and protection of natural resources. The strategic and operational programmes were comprehensive and covered most issues of biodiversity conservation, sustainable resource use and fight against desertification. The NSAD main themes were:

- Conservation of land, water and natural vegetation through sustainable utilization that ensures long-term agricultural production;
- Conservation of biodiversity in parallel to sustainable agricultural development;
- Improvement of the technical and managerial capabilities of the agricultural sector to cope with probable climate and environmental changes, and absorb their consequences;
- Halting unplanned expansion of urban areas on agricultural land;
- Combating desertification and protecting the environment, the agro-biodiversity and agricultural resources, to secure requirements for sustained development;

- Conservation of agricultural land by controlling soil erosion in steep mountainous areas, through improved agricultural practices and water conservation measures.

NSAD organized clusters of activities in subsectors: rain fed agriculture, livestock and rangeland, irrigated agriculture in the Jordan valley, and irrigated agriculture in the highlands (Ministry of Planning & International Cooperation, 2017). No information was obtained by the authors of this study on the interventions implemented in Badia.

Jordan National Agenda. The Jordan National Agenda was a vast plan launched in 2006 and implemented until 2017, with a specific section for environmental sustainability. The objectives were:

- Survey and define criteria for desertification hazards and thus map areas accordingly;
- Establish a desertification monitoring system;
- Conducting socio-economic surveys in drought threatened areas;
- Establish other alternative livelihood measures that could provide incomes in drought prone areas and arid zones;
- Documenting traditional knowledge on soil protection measures and combating desertification (Ministry of Planning & International Cooperation, 2017).

Also in this case no information was found on the interventions implemented in Badia.

National Strategy and Action Plan to Combat Desertification (NAP-2006). The Jordan NAP was launched in June 2006. The plan was coherent with the other major development plans thanks to the fact that its development was done in a participatory process including stakeholders involved in the other national planning processes (Ministry of Planning & International Cooperation, 2017).

The NAP-2006 was organized in the following programs:

- Desertification Information System (DIS);
- Drought prediction and Desertification control;
- Capacity building and institutional development;
- Restoration of degraded ecosystems of rangelands and forests;
- Watershed management;
- Human, social and economic development initiatives.

NAP-2006 provided a framework for action to combat the accelerating threats of desertification in the country, however it concrete results are considered as limited (MOE – IUCN – GEF, 2015). The constraints limiting the achievements of NAP-2006 were mainly institutional and

financial, and, as for the NES, the absence of a clear prioritization made it difficult to allocate resources. Furthermore NAP-2006 had no monitoring and evaluation plan to assess the progress of the different activities (MOE – IUCN – GEF, 2015).

The Aligned National Plan to Combat Desertification in Jordan (NAP). The Aligned NAP of Jordan was the extension of NAP-2006. It was developed for the years 2015-2020 to counterbalance the lack of practical results of the NAP-2006. Its goal is: "Productive and sustainable use and management of land resources to support poverty reduction, environmental sustainability and national economy". The Plan has five operational objectives, aligned with the strategic objectives of United Nations Convention to Combat Desertification (UNCCD) 10-years strategy:

- Actively influence relevant national and local processes and actors to adequately address desertification/land degradation and drought related issues;
- Develop an enabling environment for solutions to combat desertification/land degradation and mitigate the effects of drought;
- Strengthen the collection and use of scientific evidence and knowledge on desertification, land degradation and mitigation of the effects of drought;
- Build capacity to prevent and reverse desertification/land degradation and mitigate the effects of drought and to enable sustainable land and ecosystem management;
- Increased mobilization and improved coordination of national and external financial and technological resources.

The Aligned NAP was more structured than the previous one, with stronger emphasis on the relations among stakeholders, better financing and supported by a clear monitoring and evaluation plan. Its main goal was raising awareness about desertification, land degradation and drought among the stakeholders, generate partnerships, and coordinate the efforts of the different policies, programs, and subjects involved (MOE – IUCN – GEF 2015).

1.2.2 Large-scale restoration interventions

National Programme for Rangeland Rehabilitation and Development (1999-2006). During the Gulf Crisis of 1990-91, Jordan ecosystem resulted severely affected by massive influx of refugees with their livestock, causing overgrazing and affecting the productivity of the entire Badia region. The National Programme for Rangeland Rehabilitation and Development was funded by IFAD as the first phase of a bigger plan to revert the decline in Jordanian rangeland resources, although the idea of a bigger plan was subsequently abandoned (IFAD 2012).

The overall goal was to re-establish the productive capacity of rangeland resources, contributing to environmental, social, cultural and economic development of the Badia region. The activities conducted at the national level included capacity building in generating the information and knowledge needed to develop strategies and policies for the sustainable improvement and use of the rangeland resources. At the local level, participatory rangeland restoration and management activities were implemented in five pilot sites in North-East and South Badia. The latter were mainly based on rotational control of grazing, fodder shrub plantation, and managed grazing on the plantation sites, a scheme still followed by the most recent interventions.

The program planned to achieve the following objectives:

- Establishment of a national pastoral resources information monitoring and evaluation unit;
- Training activities for farmers;
- Construction of water harvesting and conservation structures;
- Establishment of protected areas;
- Establishment of rangeland management groups;
- Development of plans for the sustainable management of the rangeland via participatory approach.

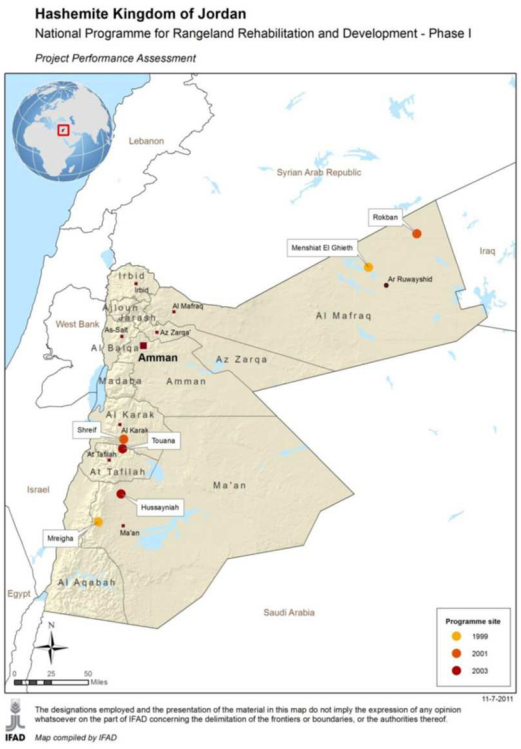

Fig 21: Map of the intervention sites (IFAD 2012)

The programme achieved parts of its objectives. The first three were successfully completed and a limited number of protected areas were established. On the contrary, the development of the rangeland management groups and of plans for the sustainable management of the rangeland was not completed or not achieved, compromising the long-term sustainability of the programme.

The below Table 21 summarizes the interventions implemented in the main project sites (IFAD, 2012).

According to IFAD assessment, the programme performed poorly during its first three years and suffered as well from the socioeconomic complexity and environmental vulnerability of rangeland management in the Badia. The overall impact was limited due to drought effects and bureaucratic issues that provoked delay in the implementation. At the end, the program was shortened and reshaped in a single-phase program (IFAD 2012).

Table 21: intervention sites and implementation progress (IFAD 2012)

Intervention site	Year	Status
Menshiat El Ghieth	1999	Restoration cycle completed: site performing water resource development, fodder shrub planting and reseeding.
Mreigha	1999	Abandoned and replaced due to unresolved issue with local communities
Rokban	2001	Restoration cycle completed: site performing water resource development, fodder shrub planting and reseeding.
Shreif	2001	Overgrazed, limited restoration unprotected.
Hussayniah	2003	Limited restoration.
Touana	2003	Limited restoration.

Badia Restoration Program (BRP). The BRP was established to face the same unresolved problem of the previous interventions. In February 2003 Jordan presented five claims to the United Nations Compensations Commission (UNCC), for remediation of damages caused by the various international crises affecting the region. One of them was for expenses of remediation and depletion of terrestrial resources. After reviewing these studies and necessary deliberations in June 2005, the Governing Council of the UNCC, awarded Jordan US $160,582,073 in compensation for the rehabilitation and restoration of Badia terrestrial ecosystem which was damaged due to the influx of refugees and their livestock (BRP, 2012). The awarding panel ruled that a cooperative rangeland management program was an effective approach to provide adequate compensation for lost ecological services in Jordan. In its decision S/AC.26/Dec.258 (2005) the UNCC developed guidelines and principles to be considered in restoration and remediation activities. In 2008 the Badia

Restoration Program (BRP) has been established, with the Ministry of Environment as National Focal Point (NFP).

The actual implementation of BRP commenced in 2011 after setting a roadmap, a baseline study and conducting two workshops in Sept. 2010 with the participation of the local communities and UNCC representatives. Based on the outputs of this design phase, the BRP Management Unit (PMU) prepared a Community Action Plan for five years (old CAP). An initial phase was approved by UNCC, as initial implementation for 2 years (2010/2011 & 2011/2012). A second phase was then drafted to cover the period throughout 2019 (BRP, 2012).

The main objectives of the BRP are:

- Reverse or mitigate damage occurred to the Badia terrestrial ecosystems with the full cooperation and participation of the Badia community;
- Restore biodiversity and productivity of land cover in the Badia as grazing resource.

The BRP Community Action Plan (BRP-CAP) defines the program specific objectives for 2011-2019:

- Identify and conduct most appropriate biophysical interventions and socioeconomic arrangements for restoring the degraded target watersheds in the Badia;
- Improve soil cover and livestock productivity in the target areas;
- Establish a sustainable ecosystem management and protection.

The program is divided in three main components:

- Integrated Watershed Management to restore degraded Badia terrestrial ecosystem;
- The socioeconomic incentives and community empowerment;
- Monitoring and evaluation (M&E).

The main interventions adopted for the Integrated Watershed Management component are micro and macro-catchment techniques. Micro-catchments are established along the contour lines, mainly according to the Vallerani Method (intermittent contour ridges), and associated with the plantation of drought tolerant fodder shrubs. The restored areas are protected after plantation by implementing a grazing rest followed by a rotation/late grazing scheme. These techniques will last for few years, maintaining the vigor and productivity of the vegetation, reducing soil erosion and enhancing soil organic matter. After the grazing rest period, restored land will be given back to local communities (local stakeholders are organized in Cooperative and Consultative Community Councils)

for sustainable management and exploitation. The project sustains a dialogue with local communities, which have a key role in implementing all the project activities starting from the selection of the sites of intervention. In addition to rangeland rehabilitation, the project provides livestock owners with vaccinations and other animal health assistance for their animals (BRP, 2012). The interventions planned, respectively, during the periods 2011-2013 and 2013-2019 are reported in tables 22 and 23.

Table 22: Old CAP (2011/2013) interventions (BRP 2012).

Watershed name	Area in Km2	Potential Rangeland Area Km2	Micro-catchment WH ha	Pond/ Dams M3	Check dams And Water Spreading m
Aranbeh	146	69	200 CCR 150 CSB	10 ponds; (1300)	4,500
Borqu	513	43	150 CSB	14 ponds; (1150)	3,000
Al Bandan	1239	136	150 CCR 500 CSR	8 ponds; (800)	500
Al Qassab	1027	122	650	8 ponds; (750)	10,000
Al Gelat	145	50	100 CCR 250 CSR	7 ponds; (600)	5,000
Total	**3,070**	**420**	**2,000**	**47 ponds; (4,600)**	**23,000**

Table 23: New CAP (2013/2019) interventions (BRP 2012)

Selected Watershed		Area in Km2	WH-techniques and management				
			Macro-catchment ponds Unit/m3	Micro-catchment ha minimum	Plantation or/and Reseeding ha minimum	Rest-rotation 4xha	Protection Guarding Man/ month 5yx12mx120
1	Hammad Corner	1401	3x100,000	2,000	2,000	4x500	60x12=720
2	Al Bandan	201	1x100,000	2,000	2,000	4x500	60x8=480
3	Al Qassab	692	1x100,000	2,000	2,000	4x500	60x9=540
4	Al Hadalat	824	2x100,000	2,000	2,000	4x500	60x12=720
5	Salma	389	1x100,000	1,000	1,000	4x250	60x9=540
6	Al Qatafi & Al Sbehi	1750	4x100,000 + 1 Dam	3,000	3,000	4x750	60x22=1320
7	Wadi Butm	528	1x100,000	1,000	1,000	4x250	60x9=540
8	Al Hazeem	58	Wild life nature reserve; *indicator for rangeland protection management*				
9	Wadi Al Ghadaf	1090	2x100,000	2,000	2,000	4x500	60x11=660
10	Swagah	200	1x100,000	2,000	2,000	4x500	60x8=480
11	Bayir	1040	3x100,000 + 1 Dam	2,000	2,000	4x500	60x12=720
12	Mafsal	177	1x100,000	2,000	2,000	4x500	60x8=480
	Total	**8,350**	**20x100,000**	**21,000**	**21,000**		**MM 7,200**
			+2Dams				
	CAP 2011	16x50,000-100,000					
	CAP 2012	15x50,000-100,000					

BRP is not an implementing agency itself. A Project Management Unit (PMU), housed at the Ministry of Environment (MoE), is the management and coordination body of the project, and its activities are implemented by different governmental entities and NGOs, in what is a rather articulated and complex organization (Table 24; BRP, 2016). As an example, the National Center for Agricultural Research and Extension (NCARE) and the Ministry of Agriculture (MoA) are in charge of micro-catchment and land restoration activities through Vallerani Method, while the Jordan Valley Authority (JVA) is in charge of the remaining water harvesting interventions.

Table 24: Distribution of responsibilities for each BRP task (BRP 2016).

BRP-CAP Project		Stakeholder/Implementer
1	Development of Macro-catchment Structures (water pond and dams)	Ministry of Water and Irrigation/Jordan Valley Authority (MoWI/JVA)
2	Development of Micro-catchment Structures (continuous contour ridges and semicircular bunds)	Ministry of Agriculture/National Center for Agricultural Research and Extension (MoA/NCARE)
3	Water Spreading and Soil Conservation Project	Ministry of Agriculture/National Center for Agricultural Research and Extension (MoA/NCARE)
4	Improving Water Quality for Livestock Watering (rehabilitation of ground water wells)	Ministry of Water and Irrigation/Water Authority (MoWI/WA)
5	Planting Native Fodder Shrubs	Ministry of Agriculture (MoA)
6	Protection and Managed Grazing	Ministry of Agriculture (MoA)
7	Facilitating Access to Watersheds (Agricultural roads to watersheds)	Ministry of Public Works and Housing (MoPWH)
8	Livestock Feed Incentives (distributing barley grains to herders)	Ministry of Industry, Trade and Supply (MoITS)
9	Improving Livestock Productivity	Ministry of Agriculture (MoA), Jordan Cooperative Coperation (JCC), Jordan University for Science and Technology (JUST), Higher Council for Science and Technology (HCST)
10	Public Awareness and Capacity Enhancement	All implementers of CAP projects
11	Smart Informal Environmental Education	Agreement not signed yet
12	Sustainable Production of Irrigated Fodder Crop through raising the height of Walla Dam	Ministry of Water and Irrigation/Jordan Valley Authority (MoWI/JVA)
13	Establishment of Rangeland Cooperatives	Jordan Cooperative Corporation (JCC)
14	Monitoring and Evaluation of CAP Projects (M&E)	The University of Jordan, Faculty of Agriculture

According to a progress report drafted in 2016 (BRP 2016), the following interventions were implemented until 2015 (Tables 25 and 26):

Table 25: List of water ponds and earth dams built within the BRP program until 2015 (BRP 2016).

Water ponds and earth dams				
Pond Name	**Watershed/Wadi**	**Coordinates**	**Storage Capacity (1000m3)**	**Completion Date**
الهقيش	Al-Bandan/Hegaish	N: 32.4448 E: 38.1880	90	Apr 2013
ابو حفنة	Al-Bandan/Abu-Hefneh	N: 32.3492 E: 38.1573	70	Apr 2013
البندان	Al-Bandan	N: 32.2356 E: 38.2313	55	Apr 2013
حليحل	Arainbah/Hlahel	N: 32.2781 E: 37.3795	87	Aug 2012
اللحفي	Arainbah/Al-Luhfi	N: 32.1903 E: 37.1909	87	Aug 2012
أرينبة	Arainbah	N: 32.2721 E: 37.0435	29	Aug 2012
الفيضة	A-Qassab/Al-Rwaished	N: 32.5765 E: 38.2481	45	July 2012
دويخلة السطيح	A-Qassab/DolkhetSteeh	N: 32.5744 E: 38.6267	99	July 2012
تلعة سلمان السفلي	A-Qassab/Tal'et Salman	N: 32.5165 E: 38.6683	101	July 2012
أم محفور	A-Bandan/Dweimet OM	N: 31.9457 E: 38.2295	100	July 2012
مرب المحدث	Borqu/Wadi Al-Muhdith	N: 32.3491 E: 37.8786	100	July 2012
الضبعي 2	Al-Gelat/AlDabee	N: 31.9327 E: 35.8986	100	July 2012
البقيعاوية 2	Arainbah/Al-Bqaiawiyeh 2	N: 32.0437 E: 37.0964	100	Oct 2013
الصبحي	Arainbah/Al-Sbihi	N: 31.8554 E: 37.6876	150	Oct 2013
تل الأقيرع	Al-Gelat/Tal-Aqiara	N: 31.8401 E: 36.2449	77	Oct 2013
جناب 2	Al-Gelat/Gnab 2	N: 31.7707 E: 36.3495	97	Oct 2013
الغصين 2	Al-Bandan/Al-Gossain	N: 32.4065 E: 37.9984	98	Aug 2013
الجعابرية	Arainbah/Al-Jabriah	N: 32.3111 E: 37.3172	100	Aug 2013
قاع ظويلة	Arainbah/Qa' Thwailah	N: 32.0366 E: 37.3420	100	Aug 2013
وادي سلحوب	Al-Safawi/Salhoob	N: 32.0118 E: 37.4293	50	Aug 2013

أخيضر الدويمي	Bayer/EkhaiderDwimi	N: 30.6078 E: 36.8216	90	Aug 2013
البوبهي	Al-Bandan/Al-Bobahli	N: 32.1641 E: 38.2178	100	Jun 2013
الغردقية	Al-Bandan/Al-Arqadiyeh	N: 32.0467 E: 38.3043	98	Jun 2013
غدير الوساد	Al-Bandan/GhadeerWisad	N: 31.8973 E: 37.9908	100	Jun 2013
الأبيض 3	Al-Qatraneh/Al-Skhriah	N: 30.9304 E: 36.1740	100	July 2013
قاع الحفير 2	Al-Qatraneh/Qa’ Al-Hafeer	N: 32.0467 E: 38.3043	100	July 2013
الحسا 2	Al-Hassa 2/Al-Baj’ah	N: 30.7687 E: 36.1089	100	Nov 2013
الحسا 3	Al-Hassa 3/Aldumeithah	N: 30.7012 E: 36.1680	100	Nov 2013
البا□جة	Al-Hassa/Al-Ba’jah	N: 30.7718 E: 36.2520	100	Nov 2013
الأحمر	Ma'an/Al-Ahmar	N: 29.8282 E: 35.9232	100	June 2015
الشيدية 2	Ma'an/Al-Shadeh 2	N: 29.8420 E: 36.0184	75	June 2015
الكريم	Ma'an/Al-krem	N: 29.8447 E: 36.1206	95	June 2015
الشمري	Ma'an/Al-Shamre	N: 30.0316 E: 35.9298	95	June 2015
ألعيرية 1	Ma'an/Aleriah	N: 30.2104 E: 36.17105	50	July 2015
العيرية 2	Ma'an/Aleriah	N: 30.2241 E: 36.18474	50	July 2015
المعدا	Ma'an/Almeada	N: 30.2442 E: 36.18523	50	July 2015
الشومري	Ma'an/Alshomare	N: 30.2808 E: 36.25545	50	July 2015
القصب 2	Almafraq/Al-gasab 2	N: 32.2724 E: 38.8892	100	July 2015
القصب 3	Almafraq/Al-gasab 3	N: 32.2607 E: 38.9532	100	July 2015
فرع الشيخ	Almafraq/Fara Al-shakh	N: 32.1766 E: 38.9474	50	July 2015
الاثنى 1	Almafraq/Alethna 1	N: 32.5313 E: 38.9644	90	under construction
السطيح 2	Almafraq/Alsateh 2	N: 32.3857 E: 38.9515	100	under construction
العون	Almafraq/Aldafianh-Alon	N: 32.2814 E: 36.5306	50	under construction
الدفيانة	Almafraq/Adafiana	N: 32.3123 E: 36.5625	1.25	under construction
الفيدان	Aqaba/Alfedan	N:30.6293 E: 35.4121	50	under construction

المصقرة	Aqaba/Almsagrah	N: 30.6237 E: 35.2914	50	under construction
نبع الطور	Aqaba/Naba Altor	N: 30.5444 E: 35.3456	50	under construction
تل شهاق	Tel Shihab/Ma'an	N: 30.5212 E: 36.1900	50	under construction
المصلى	Almosala/Ma'an	N: 30.4973 E: 36.1085	50	under construction
طليحة 2	Taliha 2/Ma'an	N: 30.4296 E: 36.0327	50	under construction
ابوغيث	Abu Ghaith/Ma'an	N: 30.3903 E: 36.1010	50	under construction
د برويش	Brieash Dam	N: 30.9039 E: 35.7855	70	2014
د الأرتين	Al artaen Dam	N: 32.0537 E: 36.5047	450	under construction

Table 26: List of micro-catchments harvesting structures built within the BRP program until 2015.

Micro-catchment water harvesting structures			
No.	Sites	Micro-Catchments Worked Areas (ha)	Construction Year
1	Al Grain	125.5	2012-2013
2		57.3	2014-2015
1	Al-Qasaab	10.5	2011-2012
2		80.8	2011-2012
3		2.5	2011-2012
4		48.1	2011-2012
5		56.3	2011-2012
1	Al-Bandan	201.1	2011-2012
2		200.3	2011-2012
3		35.8	2014-2015
4		58.7	2014-2015
1	Amaish	22.3	2011-2012
1	Arainbah	67.6	2011-2012
2		10.9	2011-2014
1	Sbohi	112.8	2012-2013
2		37.6	2012-2013
1	Al-Bobahi	140.7	2012-2013
1	Azraq	122	2013-2014
1	Al-Oshaji	44.8	2012-2013
2		74.8	2012-2013
1	Medwar Al-Gen	7.7	2013-2014
2		4.0	2013-2014
3		8.9	2013-2014
4		4.4	2013-2014
1	Dabah/Hamam Al-Shamot	50.2	2013-2014
1	Tayyarah	137.6	2013-2014

1	Al-Qatranah	206	2013-2014
1	Al-Qatranah/Thamaiel	66.5	2014/2015
1	Al-Safawi /Al Bade)	47.2	2014-2015
2		13.4	2014-2015
1	Muwaqqar	24.8	2013-2014
2		100	2014-2015

Detailed and more updated data concerning the land restoration activities implemented with the Vallerani method were verbally provided by NCARE officers to the authors, which can be summarized as follows:

- 2012/13: NCARE completed land works on 400 ha on which MoA planted Atriplex seedlings;
- 2013/14: NCARE completed land works on 600 ha on which MoA planted Atriplex seedlings;
- 2014/15: NCARE completed land works on 1200 ha, but due to various reasons MoA could plant Atriplex seedlings only on 300 ha;
- 2015/16: Extension of the 2014/15 year, no new interventions were planned, as MoA planned to complete the work previously left uncomplte. ;
- 2016/17: NCARE completed land works on 1500 ha, however Atriplex shrubs were eventually established on a much smaller surface.

Unfortunately, it was not possible to have access to detailed updated and georeferenced reports describing all the types of interventions implemented to date.

NCARE officers lament some implementation problems:

- Until 2015/16, NCARE had only 1 tractor equipped with Vallerani implement, insufficient to achieve the targets. In 2016/17 MoA and MoE acquired additional tractors improving the situation;
- Bureaucratic delay in signing the yearly agreements, sites un-easy to reach and poor collaboration with local communities provoked additional delay in the implementation;
- Poor management of seedlings caused high mortality rates;
- Proper grazing management after plantation was in several cases not implemented;
- Livestock numbers are still too high, reducing chances of long-term success.

2 Characterization of the principal types of soil and water conservation (SWC) and water harvesting (WH) interventions observed in Jordan Badia.

A wide range of sustainable land management (SLM) practices have been implemented in Jordan in the frame of different projects and programs. These could be summarized as follows:

- Conservation Agriculture (e.g., minimum tillage, improved fallows, manuring);
- Restoration of community rangeland governance and management practices, including rotational and seasonal grazing patterns;
- Improving management of ruminant animals including veterinary services and awareness programs on animal diseases;
- Rehabilitation/re-vegetation of degraded rangelands;
- Soil conservation and water harvesting measures in agro-pastoral and crop areas (e.g., terraces, contour structures and tillage, stone walls);
- Maintenance of stream beds and rehabilitation of water springs.

As underlined in the above sections, it is difficult to have access to detailed and updated information related to the achievements on the ground. When accessible, this is in many cases aggregated and not georeferenced. If available and properly used, this information would allow for an evaluation of the impact of the interventions and, besides generating significant scientific knowledge, would be of great utility to the public institution in charge for the implementation of the restoration programs.

This explains the general objective of this study, which is to generate an independent georeferenced dataset on the restoration achievements. Specific objectives are:

- to develop a consistent methodological approach to generate such dataset based on public domain remote sensing (RS) data;
- to create a pilot dataset covering specific types of interventions and defined geographic areas;
- to perform a cross-validation of the data generated, by comparison with the few institutional georeferenced data available;

- to demonstrate that with little financial resources and scientifically sound methods it would be possible to establish an effective monitoring and assessment system for Badia's restoration policies, to the benefit of the country.

This study focuses on those categories of interventions that were conducted most extensively in Badia and that have the characteristic of being sufficiently recognisable/trackable on RS images. Most of them involved the establishment of soil and water conservation (SWC) and water harvesting (WH) structures that maintain their efficiency in the landscape for several years. The interventions were georeferenced by using public domain remote sensing data. Google Earth[8] was the principal source of information due to its generally high geometric quality, although the image coverage of GE for Badia is heterogeneous (some Badia areas are covered only by old images). In these areas, a cross evaluation was done using Bing Satellite Imagery[9], where it offered more recent images.

2.1 Contour structures (CS and CSb)

Contour structures represent the biggest governmental intervention of the BRP-CAP. These consist of linear micro-catchment interventions characterized by ridges and furrows traced along the contour lines, where drought tolerant shrubs species (e.g., Atriplex species) are planted in ridges to provide a source of fodder for livestock. We identified two types of interventions, although from the images it is not always possible to distinguish clearly between the two:

- Continuous Contour Stucture (CS): this type of contour structure is established by a continuous ridge and furrow excavation along the natural contour of the slope;
- Discontinuous Contour Structure (CSb): this type of contour structure is established by an intermittent pit excavation along the natural contour of the slope, conducted by means of a Vallerani machine, a plow with a hydraulic arm;

The management of the planted area after the intervention is in charge to the local population or to the government, depending on the agreements set by the different interventions.

[8] https://www.google.com/earth/
[9] https://www.bing.com/maps/aerial

Fig 22: Continuous Contour Structure

2.2 Tank (T)

A tank is an artificial water pond built by private or governmental initiative in order to collect and stock seasonal water flows for agricultural/animal husbandry purposes. Tanks were observed all along Badia region. Their characteristics can vary, although following a common construction scheme. Tanks are usually squared, built in earth or concrete, and often connected with catchment interventions (e.g., runoff diversion structures) allowing to catch the seasonal water-flow and fill the reservoir.

Fig 23: Tank Structure

2.3 Dam (DAM)

A dam is an artificial structure typically made of concrete or earth and built to inbound water, creating a permanent or semi-permanent basin along a main waterway to support agriculture in the surrounding area. Dams are relatively big engineering intervention generally of governmental initiative.

Fig 24: Dam Structure

2.4 Check dams (SB)

Check dams are the most common interventions observed in Jordan Badia. Although their specific characteristics can be variable, usually check dams are linear structures made of earth (sometimes rock, or concrete), built transversal to the stream flow in the ephemeral river bed. The objective of the structure is to slow down the flow of water, to increase ground water recharge as well as for agricultural and anti-erosion purposes. A check dam increases water infiltration into the soil and ground water recharge, and generates a favorable area for cultivation right upstream. Water accumulated upstream sometimes creates a temporary basin. Check dams are often organized in series, built in the same time along a single stream bed.

Fig 25: Check Dam Structure

2.5 Spontaneous Hydraulic Interventions (SBb)

This type of intervention that we identified on the images and that we named “spontaneous hydraulic interventions” seem to be similar in purpose to the check dams, although it shows a more irregular structure and distribution pattern. These structures are often closely connected with other agricultural structures (like property boundaries) and probably linked to private initiative. The definition of this type of intervention will be refined after data validation.

Fig 26: Spontaneous Hydraulic Intervention Structure

2.6 Interventions located in the easternmost sector of badia in hyper arid conditions (DR, DRb and AR)

It has to be noted that most of the North-Eastern corner of the Mafraq governorate, in the desert region along the borders with Syria and Iraq, is only covered in Google Earth by old imagery (e.g., dated back to 2004/2005), as shown in the figure below.

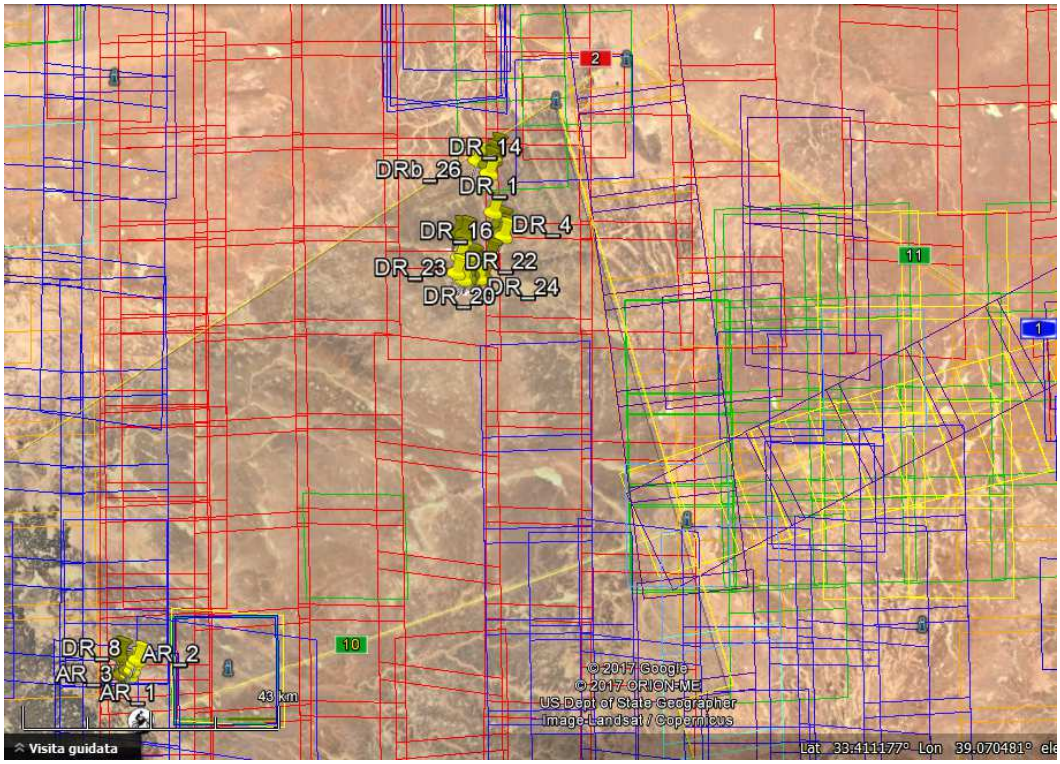

Fig 27: Satellite coverage of the Mafraq governorate. The red cells are images of 2005.

For this sector, more recent images (approximatively 2017) are available from Bing Satellite Imagery. The cross evaluation of these two sources allowed for the identification of the following types of "restoration" interventions (DR, DRb, and AR), which identification/interpretation remains uncertain and needing validation.

- DR: this category, generally named as "desert restoration", includes series of parallel linear structures drawn at a distance of around 15-25 m or 20-30 m from each other, most often (example: DR_1 to DR_5 and DR_10) in depressions or concavities in the rocky landscape, that appear to be covered by sand deposits. Hence their interpretation as dune fixation structures or more generally as sand stabilization measures. However, their prevailing E-W direction

does not seem directly related to the wind direction. In other cases, they are located on flat or gently sloping rock outcrops (example: DR_11 to DR_24). Finally, in some cases they were built in the wadi beds perpendicular to the flow direction and possibly have an aquifer recharge function (example DR_6 to DR_9). In the latter case, the average distance between the lines is 30-40 m.

- DRb: In two sites, there seem to be examples of afforestation interventions conducted in desert environment, with linear structures following the contour lines. The interventions were made on gently sloping rock outcrops and the distance between the lines varies between 25 to 50 and up to 80 m. No evidence of vegetation development was seen in the only two images available (2004 and 2005).
- AR: these structures, tentatively interpreted as “aquifer recharge” structures, are made of holes distributed in a regular grid pattern along a wadi bed and associated with other linear structures such as the DR mentioned above, or check dams and/or tanks. They have been identified in a single site but over a relatively large area, in a wide ephemeral stream where a stratification of soil and water interventions was implemented. The pattern is either characterized by a regular grid (holes at around 20 m from each other), or by groups of four holes forming squares distributed in a regular grid (10x10 m, 15 between squares).

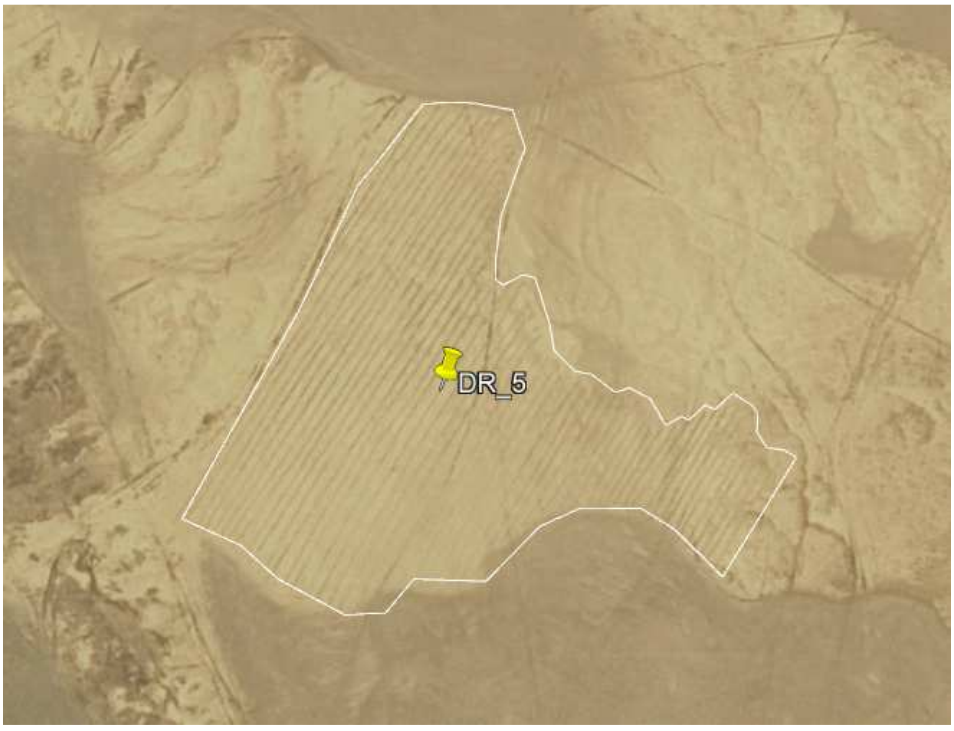

Fig 28: DR structure

Fig 29: AR structure

2.7 Reforestation intervention located in the highland area (REF)

in the highland region at the fringes of Badia we identified several large-scale interventions that in some cases first appear in 2003 images, in other cases in 2010. These interventions are most likely reforestation sites, showing various degrees of vegetation (trees and/or shrubs) development and spatial uniformity.

All the interventions are located at an elevation ranging between 600 and 1300 m.a.s.l. With one exception, they have a similar pattern/structure and they are organized in several clusters implemented approximatively at the same time. They show land works following the contour lines along the slopes, where vegetation was established. Base on their size and on the regularity of the pattern, we assume they are of institutional nature.

Fig 30: Reforestation intervention

3 The database generated

The database generated is available in Annex 3 and contains the following datasets:

Contour structures: we identified 51 sites as contour structure interventions, observed mainly in Northern and Middle Badia. 17 sites are categorized as continuous contour structures and 34 as discontinuous contour structures. The average surface of CS interventions measured with Google Earth tool is about 0.25 square kilometers, although some of them resulted too small to be properly measured and several still require validation/ground truthing, so this value has to be considered as a first approximation.

Tanks: we identified 203 tanks of different sizes. Tanks are present in all three Badia sub-regions, although not uniformly distributed. They appear to be more frequent in the north-west of the country, and rarer and scattered along the south-eastern borders with Iraq and Saudi Arabia. The average storage capacity cannot be estimated directly, but can be obtained from institutional databases as described in the following chapter.

Dams: we identified 58 interventions, mainly spread along Northern and Western borders of Badia Region. The majority seems to be operative, while a few ones appears to be still in construction at the time of photo acquisition. It appears that at least in one case, a dam was built in direct association with contour structures (CS) interventions, as part of an integrated approach. This is the case of DAM_6, b (built in association with CS_24 and CS_25) and DAM_13 (built in association with CS_65, CS_66 and CS_67). Based on approximate measurements from satellite imagery, dams have a length ranging between about 40 m and 2.5 km. The average storage capacity cannot be estimated directly, but can be obtained from institutional databases as described in the following chapter.

Check Dams: we identified 841 check dams, organized in series along the wadi stream beds. Technical characteristics and materials can vary. Based on approximate measurements from satellite imagery, check dams have a length ranging between 15 m and 2.5 km.

Spontaneous Hydraulic Interventions: we identified 115 linear structures with the characteristics described above for this type of intervention. They are often organized in cluster, interconnected and integrated within property boundaries.

Reforestation: we identified several reforestation sites, the majority of which are part of four big clusters, grouped as follow:

- Cluster 1 (from REF_1 to REF_8): located in Northern Badia, near the city of Hamra;
- Cluster 2 (from REF_9 to REF_18): located in Northern Badia, south to the city of Sabha Aldafyanah;
- Cluster 3 (from REF_21 to REF_25): located on the northern border of Southern Badia;
- Cluster 4 (from REF_27 to REF_29): located in the Southern Badia, North-West to the city of Ma'an;

A further intervention of unclear nature and purpose, coded REF_20, is located near the city of Zumayla in Middle Badia. It is isolated from the others and surrounded by check dams and tanks. It also shows a different establishment method, made of holes distributed in a regular grid. There is no evidence of vegetation development and it is unclear if it is a governmental or a private initiative.

The identified surface interested by reforestation is about 11.7 square kilometers.

Interventions located in the easternmost sector of Badia in hyper arid conditions: we identified 25 Desert Restorations (DR) sites, 2 Afforestation (DRb) sites and 3 Aquifer recharge (AR) intervention sites, showing the characteristics listed in the previous chapter.

4 Comparison with BRP and other institutional datasets

The mapped structures were compared with the dataset generated by the BRP in 2016 (Table 5) on water ponds and earth dams implemented by 2015. The comparison was only partially possible because the available satellite images were in several cases too old, particularly in eastern Badia, as already explained. In other cases, even in presence of recent images, the structures were not found (neither on GE nor on Bing), revealing possible errors of the coordinates indicated by the BRP reports.

The data generated by this study were also compared with another dataset provided by the Dam Department of the Water Authority of Jordan (WAJ), related to JVA interventions. JVA claims having been responsible of the management of about 300 water harvesting intervention since the '60s (the majority since the '90s) like water ponds, dams and check dams.

WAJ database (in Annex) enlists 363 sites, divided in three categories: dams, tanks and ponds. A pond is a relatively small earth structure, usually oval or rounded, to collect water in both rural and urban environment. Ponds have the same function of tanks, but according to the database, ponds are

usually smaller, quite old and many are currently abandoned or been substituted by other interventions. In few cases ponds correspond to structures identified by us as tanks.

The database provided by WAJ seems to be a collection of different datasets from different institutions, each one with its own coordinate system, according to the compiling institution. The coordinates were converted to EPSG4326, showing a high degree of correspondence with our database, but there are still uncertainties due to satellite photo availability and coordinate system identification.

The comparison with these databases provided additional information about several dams and tanks identified by us, such as:

- Structural characteristics;
- Construction/implementation date;
- Maintenance information;
- Funding institution;
- Storage capacity.

5 Final considerations and way forward

The abundance of intervention sites identified confirms the high relevance of Badia restoration in Jordan environmental policies. It is unfortunate that information about the achievements of the policies and programs implemented is poorly available and accessible.

This study is not exhaustive. A more systematic analysis should be conducted by means of a complete coverage of multi-temporal high-resolution satellite images to achieve an objective identification of all the interventions. Furthermore, in several cases field validation is needed to confirm the type of intervention identified. So the compiled dataset can be considered only as a preliminary elaboration and should not be used as a final product. Nevertheless, this study can represent a good starting point for any in depth analysis on the topic, providing methodological indications and a great amount of raw data to be analyzed.

6 REFERENCES

AFED/NCRD. 2014. Report of the Arab Forum for Environment and Development – Enhancing Marginal Land Productivity in the Badia of Jordan. Amman, Jordan.

Akroush S., Dhehibi B. 2015. Predicted Willingness of Farmers to Adopt Water Harvesting Technologies: A Case Study from the Jordanian Badia (Jordan). American-Eurasian J. Agric. & Environ. Sci., 15 (8): 1502-1513, 2015.

Ates S., Louhaichi M. 2012. Reflexions on agro-pastoralists in the WANA region: Challenges and future priorities. In: Acar Z. (ed.), López-Francos A. (ed.), Porqueddu C. (ed.). New approaches for grassland research in a context of climate and socio-economic changes. Zaragoza: CIHEAM, 2012. p. 511-516 (Options Méditerranéennes: Série A. Séminaires Méditerranéens; n. 102).

BRP. 2012. Community Action Plan 2011-2025 (Revised). Technical Scientific Committee in Collaboration with BRP & National Focal Point. Amman, Jordan.

BRP. 2016. Cap projects, implementers and achievements. BRP Focal Point report. Unpublished.

College of Agriculture, New Mexico State University. 2008. Preliminary Concept Paper On: Restoration of the Badia Rangelands and Increasing Income Opportunities for the Bedouin Communities by Utilizing Their Available Natural and Human Resources in Value-Added Activities. New Mexico.

Davies J., Niamir-Fuller M., Kerven C., Bauer K. 2010. Extensive livestock production in transition: the future of sustainable pastoralism. In H. Steinfeld, H.A. Mooney, F. Schneider, L.E. Neville, Livestock in a Changing Landscape, Volume 1: Drivers, Consequences, and Responses. Island Press. Washington. Pp. 285-308.

FAO, Mountain Partnership Secretariat, UNCCD, SDC, CDE. 2011. Highlands and Drylands – Mountains, a source of resilience in arid regions. Published by FAO, UNCCD, Mountain Partnership, Swiss Agency for Development and Cooperation, and CDE, with the support of an international group of experts. Rome, Italy.

FAO/IFAD. 2016. FAO's and IFAD's Engagement in Pastoral Development, Joint Evaluation Synthesis. Report No. 3909. Rome, Italy.

Gammoh I. A., Oweis T. Y. 2011. Contour Laser Guiding for the Mechanized “Vallerani” Micro-catchment Water Harvesting Systems. Journal of Environmental Science and Engineering, 5 (2011) 1309-1316.

IFAD. 2012. Hashemite Kingdom of Jordan – National Programme for Rangeland Rehabilitation and Development - PROJECT PERFORMANCE ASSESSMENT. Report No. 2525-JO. Rome, Italy.

Ministry of Agriculture, Directorate of Rangelands and Badia Development. 2013. Updated Rangeland Strategy for Jordan 2013/2014. Amman, Jordan.

Ministry of Planning & International Cooperation. 2017. National Sustainable Development Report (2016/17), Desertification - Strategic planning frameworks for the protection and sustainable management of natural resources in deserts and areas affected by desertification, their integration into national development strategies and/or action plans. Amman, Hashemite Kingdom of Jordan Available from: http://www.un.org/esa/agenda21/natlinfo/countr/jordan/desertification.pdf

Myint, M.M., & Westerberg, V. 2015. An economic valuation of a large-scale rangeland restoration project through the Hima system in Jordan. Report for the ELD Initiative by International Union for Conservation of Nature, Nairobi, Kenya. Available from: www.eld-initiative.org

MOA – IUCN. 2015. Sustainably Investing in Rangelands – Jordan. Amman, Jordan.

MOA – MOE. 2014. Badia Restoration Program (BRP) - Inception Report of the "Rehabilitation of Degraded Rangelands in the Badia" of the BRP-CAP. Amman, Jordan.

MOE. 20??. National Strategy and Action plan to Combat Desertification. Amman, Jordan.

MOE – IUCN – GEF. 2015. The Aligned National Plan to Combat Desertification in Jordan – 2015/2020. Amman, Jordan.

University of Jordan. 2015. 1st Progress Report of "Monitoring and Evaluation" Project of the BRP-CAP Projects, September-December 2014. Amman, Jordan