SUSTAINING MOROCCAN OASIS AGRICULTURAL SYSTEM THROUGH SMALL MECHANIZATION INPUTS

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Sommario

Le oasi sahariane rappresentano un ecosistema artificiale che nei secoli si è dimostrato economicamente produttivo, nonostante il suo fragile equilibrio. Elemento portante è la buona gestione del palmeto che permette lo sviluppo di una struttura a tre livellie un microclima favorevole all'agricoltura.Questo ecosistema va oggi incontro a una progressiva degradazione, causata da fattori climatici, economici, sociali. La mala gestione del palmeto, causata dalla mancanza di risorse umane e materiali, è la causa principale del collasso dell'intero ecosistema.L'introduzione della piccola meccanizzazione può rinvigorire il sistema agricolo locale e rappresentare un fattore di attrazione per i giovani verso questo settore.

Abstract

Saharan oases are a highly artificial ecosystem that has proved to be economicallyviable for centuries, despiteits'fragile equilibrium. The pillar of this ecosystem is the good management of the palm grove, which allows the establishment of a three-layer structure and of a microclimate favourable for agriculture. Nowadays oases ecosystem is at risk, endangered by climate changes and economic and social factors and the poor management of the palm grove,caused by lack of human and material resources,is the main cause of its' collapsing. The introduction of small mechanization can provide tools to invigorate this farming system and attract young people in the agricultural sector.

Keywords:

date palm, harvesting, light mechanization, 2-wheel tractors, migration.

Introduction

An oasis is in most cases an artificial ecosystem, that thanks to human intervention is capable of sustaining agriculture under arid climatic conditions, like the Sahara Desert. The traditional system requires some degree of collective management for plants, soil and water but has proved to be sustainable and productive for centuries. Usually an oasis has a 3-layer structure, where the palm

grove represents the most important element: date palms form the upper layer and protect from excessive insolation the fruit trees (figs, almonds, olives, pomegranates etc.) and the arable crops (barley, wheat, sorghum, alfalfa and various vegetables) of the two lower layers, hence contributing to the formation of a mild microclimate. A well-managed palm grove is vital for the maintaining the traditional oasis structure (De Haas, 1998).

Oasis systems have also a strong connection with animal husbandry, historically represented by trade relationship between sedentary and nomadic people. Animals grant food or traction force for transport, water extraction and tillage and produce manure to increase soil fertility and feed on the fodder produced in the oasis (figure 1).

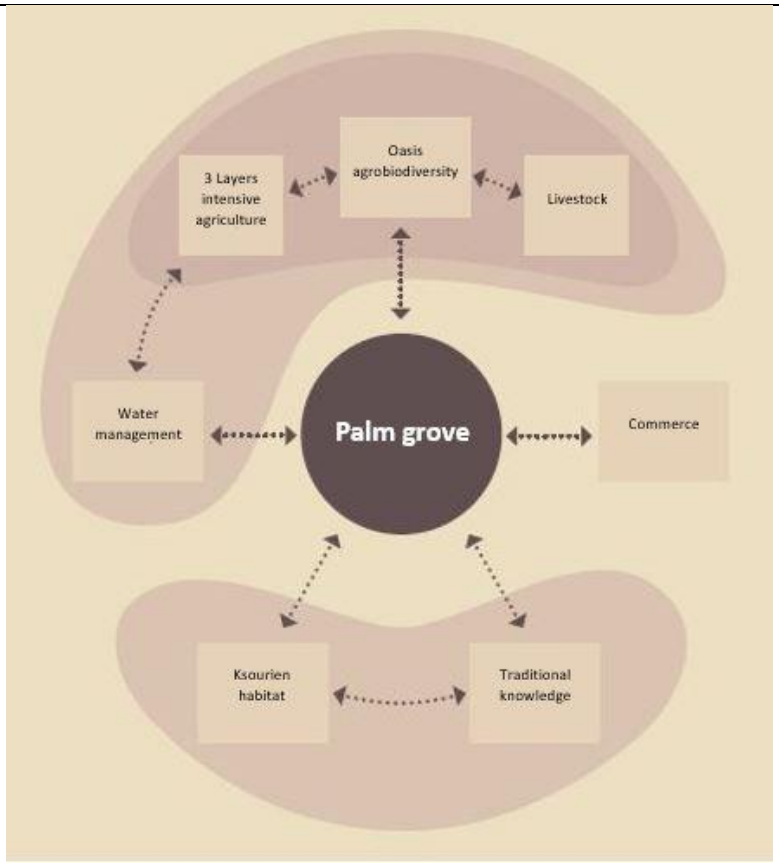

Figure 1 – Traditional oasis organization (Adps, 2015)

Nowadays, due to migration, socio-economic and political changes traditional oasis agriculture is in serious danger almost anywhere. Land use 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 (De Haas, 2001); figure 2 shows the reciprocal effects of criticalities and palm grove health.

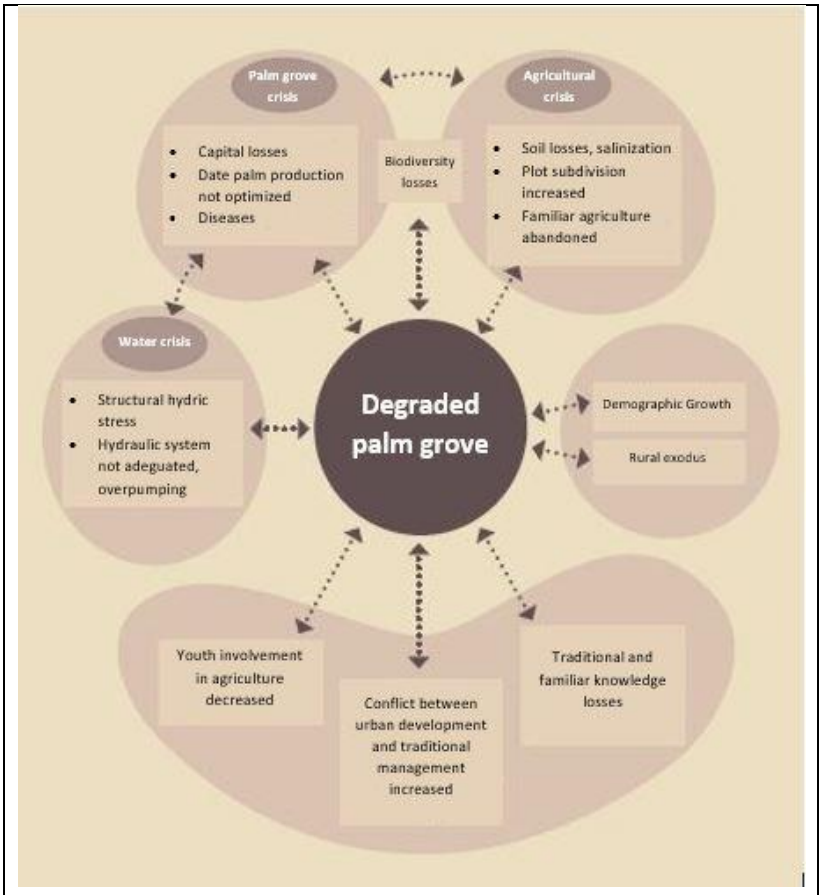

Figure 2 – Degraded oasis system (Adps, 2015)

In the Kingdom of Morocco many actions have been planned and implemented aiming to hinder oasis abandon and degradation, either by the Government or by other bodies, such as local administrations, international organizations, NGOs, cooperation agencies of other countries etc. This paper briefly describes the contribution of the authors based on the possibility of introducing mechanization in the traditional oasis farming system to increase labour productivity and reduce drudgery, hence allowing to make this neglected work more attractive and rentable.

This analysis is still in progress and has proceeded through a sound assessment of the actual situation, identifying constraints and potentialities, through a sound investigation on all what has been done or is on-going until now and through interviews to the main stakeholders of the Moroccan oasis farming system.

Oasis agricultural system and date production in Morocco

The analysis, that has not yet been completed, has been conducted through a review of some of the main programs implemented to sustain oasis economy in the last decade, together with direct interviews to various stakeholders involved in the oasis farming and date production in the main areas of south-eastern Morocco. A list of selected oasis and stakeholders is shown in tables 1 and 2.

Table 1 – Oases selected for survey and interviews

Name	Province	Region	Oued
Agdz	Ouarzazade	Sous-Massa-Draa	Draa/Zagora
Aoufous	Errachidia	Tafilalet	Ziz/Errachidia
Erfoud	Errachidia	Tafilalet	Ziz/Erfoud
Errachidia	Errachidia	Tafilalet	Ziz/Errachidia
Figuig	Figuig	Orientale	Zouzfana/Lakbir/Bouchlikhen
FoumZguid	Tata	Guelmim-Es Semara	Draa
Goulmina	Errachidia	Tafilalet	Gheris
Jorf	Errachidia	Tafilalet	Ziz/Erfoud
Lblida	Ouarzazade	Sous-Massa-Draa	Draa/Zagora
M'Hamid	Ouarzazade	Sous-Massa-Draa	Draa/Zagora
Ramlia	Errachidia	Tafilalet	Ziz, Rheris
Rissani	Errachidia	Tafilalet	Ziz/Erfoud
R'tbe	Errachidia	Draa-Tafilalet	Ziz
Skoura	Ouarzazade	Sous-Massa-Draa	Dades/Ouarzazade
Soul ElKhémis	Ouarzazade	Sous-Massa-Draa	Dades
Taamegroute	Ouarzazade	Sous-Massa-Draa	Draa/Zagora
Taghjicht	Tiznit	Guelmim-Es Semara	Boulgor
Tata	Tata	Guelmim-Es Semara	Draa
Tinghir	Ouarzazade	Sous-Massa-Draa	Todra
Zagora	Ouarzazade	Sous-Massa-Draa	Draa/Zagora

Originally this analysis was aimed at the whole date chain but, due to its complexity, only the field production phase has been taken into account in this first step, because it appears to be, at the present, the most critical one.

Moroccan 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. However, they make no exception in the global trend and they are severely affected by diseases, bad management and abandonment problems.

The structure of these oases is based mainly on date palm cultivation and arable parcels that are cultivated with alfalfa or cereals to be used as fodder; the second layer is mostly constituted by olive trees, scattered or planted in rows while other fruit trees are scarcely present. Fodder and olives are principally destined to self-consumption or anyhow are not considered important in the farming economy, while dates, even of the less valuable varieties, can constitute an important source of income.

Table 2 –Main stakeholders in oases farming system development (Auatif Chapron, 2015; Fratucello, 2016; Kradi, 2012; Pnud/Agense de l'Oriental, 2008; Programme de Développement Territorial Durable des Oasis du Tafilalet, 2010; Toumi, 2008; UN climate change conference Cop22, 2016).

Name	**Type**	**Description**
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.
Agence Nationale pour le Développement des Zones Oasiennes et de l'Arganier (Andzoa)	Public institution	A structure founded in 2010 and dedicated to fighting desertification and preservation of biodiversity.
Agence pour la promotion et le développement économique et social des provinces du Sud du Royaume (Adps)	Public institution	The agency's mission is to assist and coordinate national and local subjects in defining development strategies and accessing economic resources, in order to sustain the development of the southern area of the Kingdom
Agriculturalcooperatives	Cooperative	A wide range of collective organization: family

		cooperatives, production cooperatives, transformation cooperatives and service cooperatives.
Belgian Development Agency (Ctb)	Belgiancooperation agency	Active in southern Morocco with 2 projects concerning date palm: PaGie, supporting the Gie organization, and Safran-Dattes, a value chain analysis.
Centre d'Etude et de développement des territoires oasiens et désertique (Cedtod)	Association	A liaison center between research, Government services and farmers. Engaged in practical actions such as khettara rehabilitation and modernization, drop irrigation and other water provision methods development in oases
Direction de l'Aménagement du Territoire (Dat)	Public Institution	A branch of the Ministère de l'Aménagement du Territoire National, de l'Urbanisme, de l'Habitat, et de la Politique de la ville, in charge of development programs.
EconomicInterest Group (Gie)	Economicconsortium	A Gie is consortium of cooperatives created to gain a competitive advantage. Date Gies are a recent creation, not yet completely operative. They act mainly an interface with governmental institution, but provide also storage and marketing services for the producers.
Fédération Interprofessionnelle Marocaine des Dattes (Fimadattes)	Producersassociation	The federation represents producers from Ouarzazate, Figuig, Guelmin, Errachidia, Tinghir, Zagora and Tata, the most importat areas of date production. It acts as a Union towards the Government institutions and carries out coordination and training of associates.
German Corporation for International Cooperation GmbH (Giz)	Germancooperation agency	Works in Morocco since 1975 supporting projects about sustainable development, water harvesting, renewable energy, climate change, good governance and health. It is active in southern Morocco with 2 projects concerning

		oasis farming system: Re-Activate and Pedel.
Initiative Nationale du Développement Humain (Indh)	Public institution	Assists the Government in improving inclusiveness, accountability and transparency of decision making and implementation processes at the local level in order to enhance use of social and economic infrastructure and services by poor and vulnerable groups.
Institut National de la Recherche Agronomique (Inra)	Public institution	A public research institution for agricultural development. It has 10 regional research centers and 23 experimental stations in the different Moroccan ecosystems.
Ministry of Agriculture and Fisheries	Public institution	The Ministry is the most important subject, involved in almost all the main agricultural projects.
Office National de Sécurité Sanitarie des Produits Alimentaires (Onssa)	Public institution	The agency is involved in the sanitarian protocols for plants, animals and food products.
Office National du Conseil Agricole (Onca)	Public institution	In charge of piloting and coordinating the fulfillment of the national agricultural council strategies of on national scale. They are providingextension service to farmers
Office Régional de Mise en Valeur Agricole de (Ormva)	Public institution	An operational branch of the Ministry of Agriculture, it represents the Government on the territory and has an office in each region.

Moroccan date sector covers 48,000 ha of date palm plantations, encompassing 4.78 million palm trees. Producers are estimated to be over 200,000, mainly small-holder farmers, of which about 10% are organized into cooperatives. The main date producing regions in Morocco are Errachidia, Figuig, Ouarzazate/Zagora and Tata (figure 3 and 4), accounting for over 90 % of domestic production (App, 20xx).

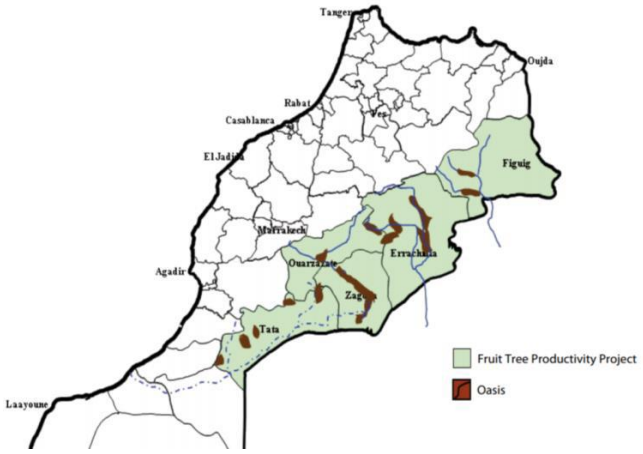

Figure 3 – Main area of date cultivation (App, 20xx)

Figure 4 – Palm groves in the Draa Valley near to Zagora

In the Drâa-Tafilalet region date producers are estimated to be almost 80,000 according to Ormva officers, while the hectares covered by palm groves are about 41,000, so the average surface for each producer is about 0.5 ha or less, considering the larger modern plantations recently set up by new investors. In Tafilalet only the average surface for each producer is slightly lower being about 0.4 ha (Ormvat, 2012). In intensive plantations palms are spaced about 8 m x 8 m, making the investment around 160 plants/ha, but in traditional groves palms are scattered and often intertwined while large fails are caused by aging or diseases making the average investment about 100 plants/ha (Ormvat, 2012). In this region, the average yield of a date palm is 29 kg/year (Ormvat, 2012), even if, depending on age, cultivar and management the yield can reach up to 200 kg/year.

Among numerous existing date palm varieties (223 are known while the unnamed hybrids, referred to as khalt, are estimated to be about 1,800); single producers normally have khalts in their groves mixed with some more precious indigenous varieties such as Bou-feggous, Bous-kri, Jihel and Mejhoul (App, 20xx), though many others are also appreciated by local consumers. In particular Mejhoul is considered very valuable and is, at the present, the most planted in Morocco, due to the high cost of its fruits. Mejhoul and Bou-Feggous are cultivated mainly as cash crops and plantations or single trees are usually well managed and constantly renovated.

Khalts are characterized by extremely variable characteristics, yield and quality; they are not much requested in the market, though often their abundance compensates for low prices, so they are never present in new plantations; they provide however a good integration in animals' diet and on an ecological and long term perspective they are very important because of their diversity and constitute an important genetic reserve. This is one of the reasons why maintaining the old groves alive has not only an economical and cultural meaning, but also a strategic importance.

Date production chain

Agricultural operations and management practices can vary, according to the kind of farm and to the structure of the plantation (traditional, specialized etc.), so not always what are considered the 'best practices' are applied. In some cases, farmers in traditional groves devote diversified attentions to their plants, depending on the variety, in other cases they do the minimum to keep plants alive and productive, while others devote to them all the care that is needed.

The main farming operations in date palm cultivation are listed in table 3 together with the technique most commonly used in Moroccan oases.

In general, there is a very limited use of machines, even if the reasons are different in traditional and modern farming systems. Traditional farmers usually are not willing to invest, having only a limited amount of land, and the subdivision in small plots, often scattered, makes it difficult for motorised equipment to move around easily. Modern plantations instead are mostly still in the initial phase, where trees are of small size and operations are done easily by standing or, in some cases, with the use of a simple ladder.

Table 3 – Farming operations for date palms as carried out in Morocco

Farming operation	**Management**
Soiltillage	Rarely done manually. Animal traction is used in small farms, tractor in larger ones
Fertilizing	Manually by spreading manure in smaller traditional farms, mechanized with use of mineral products in large ones
Irrigation	Ditches and channels in traditional groves, drip irrigation in modern plantations
Pruning of leaves	Manually by climbing the palm with ladders or belts
Pollination	Mostly manually by old men by climbing the palm, difficult to find young operators.
Cleaning of palm/trunk	When done is a manual operation, with the use of a chisel
Thinning of flowers	Rarely done in traditional groves, even for valuable varieties. Operators have to climb the palm
Fruitprotection	Rarely done in all environments. Operators have to climb the palm
Spraying	Almost never done. When done must be mechanized
Harvesting	Always manual, done by climbing the palm with ladders or belts

Identified problems

The following are the main problems that have emerged from the survey and from literature review (Kradi et al., 2002).

- Bayoud disease: it is perceived as the main problem by farmers and institutions, responsible of the destruction of the ecosystem of many oases, has caused the depreciation of many groves and discourages investments.
- Lack of water and salinity: water availability represents a big problem for the region. Some traditional farmers still use irrigation channels fed by the old khettara system, but almost everyone has a well with solar pump as back-up. The increasing number of wells and irrigation basins set up without a clear regulation could represents a future threat for the sustainability of the aquifer.
- Poor management and lack of optimization of water resources for irrigation

- Lack of interest and caution by young generation: young people are not interested in agriculture, especially considering the risks of traditional farming system for the management of big palms.
- Financial resources: almost everyone laments the lack of money to invest.
- Lack of specialized workers during the period of higher need.
- Need for time taking and laborious operations, sometimes dangerous (climbing), that are often not worth doing.
- Poor logistic for transport and marketing: this is especially true for remote rural locations. The road network is inadequate and the connection with important marketplace is limited.
- Degradation of groves caused by desertification (depending on the area): the advancing of sand erodes year by year more surface (figure 5) and farmers spend a lot of energy in trying to control it and often react by planting new plots farther, but the new ones are specialized and there is loss of biodiversity;
- Low quality of dates and processed products due to the lack of appropriate equipment.

Proposal

Traditional cultivation practices are time-taking and tiring and discourage young people from taking up their parents' job. In other cases, plots have been inherited by persons who don't have agricultural skills and are busy with other works and don't find it convenient to hire labor for tending the groves, sometimes it is even difficult to find manpower. As a consequence, traditional groves are mostly abandoned or poorly tended, where the owners reduce to a minimum cultivation and just settle for what the plants naturally produce.

In this situation mechanization of all possible operations can provide a new incitement and make the field work more attractive for the younger ones thus valorizing their role, enhance labor productivity and skills and reduce fatigue considerably. In the case of climbing up the palms the use of motorized lifting devices would also have an impact on workers' safety. Mechanization of post-harvest and processing phases can also increase women engagement in date chain and should be subsequently taken into account.

Introducing mechanization in Moroccan oasis is technically and technologically possible though specific tools for palm cultivation do not really exist; 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 previously described.

Optimization of the working time and the valuation of the work of the young people and the woman by the mechanization.

Figure 5 – Advancing sand dunes

Introducing mechanization

In modern agriculture mechanization has allowed to increase noticeably work outputs, reducing work drudgery and, when correctly applied, protecting worker's health and increasing safety. However, one on the main limitations of mechanization remain the relatively high investment costs and the need for scale economy, which make it difficult to access by many farmers and particularly by smallholders. Increased power availability for farm work in most cases 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. Mechanization interventions should be carefully designed taking in account adequacy, appropriateness of technological level, correct sizing and 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.

In the case of Moroccan oases farming system, as previously described, the most suitable mechanizing intervention appears to be the one based on light mechanization, which means small 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 within small plots with ditches and scattered palms and other tree crops or obstacles, performing the essential operations needed for rehabilitation and cultivation of groves, such as tillage and transport together with other important ones like ditching and mulching. These machines are simple to use and maintain and have some similarity with tools and operations for animal traction that is still widespread in this environment. Light mechanization also includes small size specialized equipment such as dumpers and excavators, mounted equipment such as sprayers and platforms (figure 6) and various tools (shears, chisels, chainsaws, shakers etc.) driven directly or indirectly (by electricity or compressed air) by the engine of the main machine.

A proposal for setting up a pilot unit is being drafted with the aim of testing 2 or 3 of these units in different areas in order to evaluate benefits and constraints of introducing small mechanization in Moroccan oases traditional farming system, together with its technical and economic feasibility.

Concerning these two last 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 4 shows an example of typical cost and working capacity of a motocultivator, a trailer and a small self-moved platform.

Being the average property usually quite small, in the range of 0.4-0.5 ha as seen in the previous paragraphs, a complete set of equipment should be managed in a cooperative form by groups of farmers or by an independent contractor. In the first case cooperatives of farmers 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 brings to misuse and poor maintenance.

Figure 6 – Light equipment is affordable and can move nimbly even in tight groves

Equipment ownership and management by a specialized independent entity such as a cooperative, a NGO or other is a more modern solution were the operators are specialized and can assure the best use of the equipment together with correct agricultural practices. This kind of approach is taking place in many realities in DC, where smallholders need access to mechanization, and can take different forms, also adopting up-to-date technology and business models from other initiatives in industrialized Countries. This is the case of a start-up company in Nigeria that sells two-wheel tractors equipped with GPS and links farmers to owners through a cell phone text messaging system, another one in India that has set up an Uber-type service for hiring a tractor with a driver and a NGO in Zambia that leases equipment providing various services, including financial assistance and training, and an Airbnb style agricultural equipment platform which is being setup in West Africa (Cta, 2017).

Table 4 – 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-wheeltractor	10-12 kW	rotary tillage	workingcapacity ~50-100 m2/h	~5,000 Eur
Trailer*	-	transport	payload:~400 kg, speed:~5 km/h	~2,000 Eur
Self-movingplatform	9 kW	access to palm crown level for 1 operator	time for positioning, lifting and lowering: ~4 min	~30,000 Eur

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

Conclusions

Enhancing date production appears to be one of the possible actions for sustaining oasis economy and most public projects are aiming at this objective. Sustaining farmers' activity through light 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, but economic benefits of mechanizing traditional palm groves are yet to be proved. 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.

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.

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