



## Advanced and emerging agricultural innovations for securing food, climate and ecosystems in Moroccan oasis

Rachid Mrabet<sup>1\*</sup>

<sup>1</sup>National Institute of Agricultural Research (INRA-Morocco)

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#### \* Corresponding author

[rachid.mrabet@inra.ma](mailto:rachid.mrabet@inra.ma)

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### Abstract

In Morocco, oasis ecosystems cover 15% of country's lands and are bright spots of rich biodiversity and multi-functionality but hot spots of land degradation, social vulnerability and water and food insecurity. Hence there is a need to shift from assessing risks and hazards in these ecosystems to effectively capture key drivers and pursue solutions and measures to reduce vulnerability and enhance adaptive and productive capacity. In other terms, the food-environment dilemma requires urgently revitalizing these fragile agro-ecosystems in order to re-nurture the population, to strengthen society growth and food-related value chains and bring back resilience and sustainable development. In doing so, it is imperative to enforce, develop and encourage adoption of state of the art but adapted innovations and support knowledge sharing processes and approaches that drive implementation and up/deep scaling of innovations within ecosystems and by communities. A large array of innovations and technologies is emerging pertaining to advanced biotechnology, agro-ecology, smart-irrigation management, disease monitoring, control and safety, food industry, livestock, soil security, landscape management and institutional policy and governance. The paper seeks to present an integrated view of these stock takes and how they can help in addressing simultaneously climate change and food security, spatial prioritization, closing gaps, strong interfacing of society and ecology and achieving land degradation neutrality.

### 1. INTRODUCTION : OLD ISSUES BUT NEW EMERGENCIES

The human and nature are dynamically intertwined and embedded in the oasis, placing vulnerability, shocks and extreme events as part of this dynamic (Ben Salim, 2014; Ait El Mokhtar et al., 2019). In other terms, the resilience and hence sustainability of oasis agriculture and ecosystems at large are questioned due to major negative environmental and socioeconomic impacts (Ait El Mokhtar et al., 2019).

In Morocco, oasis ecosystems cover a total area of 115 563 km<sup>2</sup> that is 15% of country's land area (HCP, 2014; OASIL, 2016) where farmers and their value chains and capital are considerably affected by harsh climate, water scarcity, food insecurity and rural poverty. These ecosystems are home to over 1.7 million people (5% of the population).

In other terms, the fragile alliances and drivers of resilience and productive capacity of oasis ecosystems should be revitalized and strengthened through enhancing water-food-energy and climate nexus and associated framework and governance. Improving the prospects of the rural poor in Morocco's oasis requires higher household and farm incomes, sustainable farming practices, and more diverse income opportunities.

The date palm sector contributes to the formation of agricultural income up to 60% for a 1.6 million inhabitants. With the exception of some modern date palm farms, the agricultural practices are generally traditional in oases. Date production has witnessed increasing importance as it makes a substantial contribution in enhancing food security, reducing

unemployment, and strengthening income generation in rural areas.

The Green Morocco Plan has revitalized the economy of one of the country's most fragile regions. The sector has generated an added value of 1.3 billion dirhams annually between 2015 and 2018 and promoted export of date of 300 tons between 2010 and 2019 annually compared to only 82 tons for the period from 2003 and 2007. The area of land dedicated to the Date palm marked a clear increase of 25% from 48,000 ha in 2008 to 59,600 ha in 2019. The date production increased by 50% from 68,000 tons between 2003 and 2007 to 102,000 tons between 2010 and 2019 (MAPMDREF, 2022a). However, increasing cultivation of date palm in the recent years as a monocrop has resulted in new challenges. The varietal structure of new palm groves, dominated by Mejhoul and Nejda, could constitute a long-term constraint.

Mejhoul is a noble variety that is well known internationally thanks to its excellent market value (Sedra, 2012; Zaid and Oihabi, 2022). Several landmark studies have shown that the Mejhoul variety is a landrace variety of Moroccan origin (Zaid and Oihabi, 2022). It occupies a privileged place within the national varietal heritage, especially with the planting of 2.9 million plants as planned by the date palm program, of which the Mejhoul should constitute 67%. Within the new agricultural strategy, Moroccan government is planning for a second extension of its date palm plantations (of about five million date palms) with a special focus on the Mejhoul variety.

Morocco's date palm sector is vulnerable to drought despite the sector's proven resilience to climate factors. Yet, desertification vulnerable areas continue to expand in tandem with an ongoing population expansion in those climatically challenged regions (Dahan et al., 2012). As such, Government can or should take proactive and cost-effective action to protect the sector's long-term resilience and productivity in hindsight of building regenerative ecological systems.

Still major improvements to food systems are conceivable with adoption and scaling of more sustainable farming practices and innovations, both at farm and ecosystem level. In this regards, a range of innovations has been proposed by the research community to improve farm sustainability and ecosystem health in order to support farmers in progressing in agricultural and food systems or engage policy makers in

alleviating poverty, institutional and development barriers.

In continuity of efforts from the Green Morocco Plan, the newly launched Green Generation strategy (2020-2030) has called to engage on agri-food systems transformation, foster innovation and technologies, develop entrepreneurship and improve the oasis capacity to adapt its food systems so that they are more productive, more resilient, more inclusive and more sustainable, and deliver healthy food for everyone (MAPMDREF, 2022b).

## 2. GLOBAL SEARCH FOR ALTERNATIVES: REVIVING "OLD" LANDS

The oases have known, throughout history, to adapt to difficult climatic conditions and were key nodes on trade routes and through the desert. They are home to large and diverse communities in the Middle East and North Africa (> 1.5M inhabitants in Morocco). In addition, the oases have an exceptional natural, cultural and architectural heritage.

The oases are exemplary and unique agricultural production spaces. They are areas of intensive agricultural production in a region dominated by an arid climate. There are also home of specific ancestral irrigation techniques (e.g. Kheffara and Saguia) that are unique and smart systems of exploitation and water saving. The economy of Moroccan oases is essentially based on the exploitation of palm groves (date palm, underlying crops and by-products) in addition to pastoral farming.

Bouaziz et al. (2017) reported that oases are both very specific due to strong climatic constraints, but also very much integrated into major contemporary developments: tradition/modernity, evolution of local communities, and private actors, specificities of terroirs, concern for the sustainability of natural resources, environmental concerns. Fassi (2017) suggests that the oasis zone is at the forefront of a more universal reflection on the ecological transition towards sustainable development.

Enhancing biodiversity in agroforestry systems is suggested to promote ecosystem services, thereby reducing dependency on agronomic inputs while maintaining high crop yields. Overall, diversification enhances biodiversity, pollination, pest control, nutrient cycling, soil fertility, and water regulation without compromising crop yields and quality. However, in oasis ecosystems such benefits are reduced due to impacts of climate change (especially drought and salinity), mis-use of resources and

aggressiveness of Bayoud disease (Karmaoui et al., 2014; Jilali and Zarhoule, 2015). In this regards, farmer communities are losing the options to make diets healthier and food systems more resilient and sustainable and accompanied by increasing food waste, a growing malnutrition burden and unsustainable environmental degradation. In other terms, rising system-wide turbulence in oasis ecosystems calls for transformative change towards sustainable futures.

In 2010, Sharif et al. recommended the inclusion of the planting of date palms as part of carbon offset projects which would be incorporated into an overall sustainable development agenda of Arab region. Henceforth, policy should be oriented towards a new or emerging management of oasis food systems to contribute to well-being and sustainability of societies and farming communities. Among such policy engagement and for a balanced vision on the different dimensions of sustainability and high systemic efficiency, sustainable oasis initiative was propelled at the occasion of COP22 in Marrakech and is implemented within the newly launched agricultural strategy (i.e. Green Generation 2020-2030). This initiative calls for food systems sufficiently productive (to meet human nutritional needs) whilst imposing few costs on the environment and society (so being sustainable), and highly efficient at all stages of the food chain so as to minimize waste and engage oasis systems in circular economy (ANDZOA, 2022).

The ongoing impact of oasis ecosystem degradation on business performance and household incomes could inhibit new development because of increased climate and disease risk. Morocco's Date palm sector is characterized by a traditionally low-maintenance approach to palm tree care, and concerned growers lack the skills to manage unprecedented climate and disease effects. Within oasis, the main triggers that stimulate efforts to increase production efficiencies and sustainability are land scarcity, investments in crops and livestock and sponsored development initiatives (especially incentives and subsidies to farmers and value chains). In other side, the government should either adapt technology to the level of management capability or increase management skills to cope with modern, sophisticated and emerged technologies in irrigation, crop and livestock management, plant health and food transformation.

## 2.1. Date palm breeding & biotechnology

Date palm (*Phoenix dactylifera* L.) constitutes the keystone species of the Moroccan oasis ecosystem. However, Bayoud, caused by *Fusarium oxysporum* f. sp. *albedinis*, is one of the date palm diseases which is difficult to control (Bouhlali et al., 2020). The elite commercial cultivars have shown high susceptibility to the disease. In order to combat this disease, the use of resistant cultivars appears, up to now, the only practical means to protect and cultivate date palm trees, even in the presence of the disease (Mazri et al., 2019). Although complex and requiring time it is promising and the genetic approach was adopted by INRA (Institut National de la Recherche Agronomique) in Morocco in the 1960s. Genetic improvement of date palm has permitted the selection of cultivars combining good fruit quality and resistance to bayoud. Based on advances in plant tissue culture, micro-propagation technique has been developed for the rapid mass propagation of date palm. Micropropagation of date palm through somatic embryogenesis and organogenesis reduces labor cost and time.

The results of this program were conclusive and several bayoud resistant varieties and clones were selected by INRA (Sedra, 2015), in particular the varieties Sedrat (INRA-3003), Najda (INRA 3014), Daraouia (INRA 1445), Mabrouk (INRA 1394), Al Amal (INRA 1443), Bourihane (INRA 1444), and Al Fayda (INRA 1447). It was reported that cv. Al-Fayda produces fruits of excellent quality and is resistant to bayoud disease (Mazri et al., 2019).

Other varieties have been selected for other date qualities: Ayour (INRA-3415), Hiba (INRA-3419), Tanourte (INRA3414), Al Baraka (INRA-3417), Tafoukte (INRA-3416), Khair (INRA-3300) in addition to male cultivars (Nebch-Bouskri (INRA-NP3) and Nebch-Boufeggous (INRA-NP4)) (Sedra, 2011).

Due to Green Moroccan Plan, especially Najda cultivar which is both of high fruit quality and bayoud resistant (Mazri et al., 2021) was multiplied on a large scale in order to contribute to improve the quantity and quality of date production, leading to increased farmer income and the promotion of human development in the Saharan areas (Noutfia et al., 2021).

The development of these new cultivars is meant for the rehabilitation of areas devastated by the

Bayoud. However, Date palm micropropagation depends on various factors which include tissue browning, hyperhydricity, explant source, age of explant, size of explant, cultivars, intensity and quality of light, temperature, pH of the medium, plant hormones, culture medium composition and age of culture (Mazri and Meziani, 2015; Meziani et al., 2019a, b). The use of inflorescences for the in vitro multiplication by organogenesis of the selected clones is a promising non-destructive method (Meziani et al., 2016). Propagation through organogenesis was reported to be very interesting mainly because it permits the preservation of true-to-type of multiplied plants (Mazri et al., 2017; Abahmane, 2017). So more advanced research is still carried out by study teams and consortium in order to improve further these techniques using bioreactors, reduction of formation of hyperhydricity in the cultured tissue, improved medium composition and acclimatization of plantlet for higher survival rate for examples (Mazri et al., 2021).

In fact, although genetic improvement has effectively managed the disease in infested areas for decades, the use of a single variety will generate selection pressure on the populations of Bayoud which risks evolving into new races capable of overcoming resistance mechanisms. Therefore, it is time to deploy new resistant varieties, with diverse resistance mechanisms, to warn against, and anticipate, the eruption of a devastating epidemic of date palm heritage. Accordingly, the mass selection program has given birth to a new series of 7 varieties of good fruit quality whose verification of disease resistance is in progress. In a view of that, the use of varietal mix will reduce the populations of the pathogen to very low levels, which will stem the expansion of Bayoud inside the infested palm groves and therefore reduce the imminent risk of its introduction into unaffected areas. One of the levers to prevent the spread of Bayoud and eventually other diseases and pests is to mix and diversify the varietal resistances by focusing on the compensatory effects. This innovation practice can limit the economic loss by ensuring the existing yield stability of the palm. Furthermore, in the climate-changing context, this alternative should be further explored and made technically feasible. The non-biological origin stresses (like water and drought stresses) would be less acute and frequent, due to the synergistic capacity of water absorption and fertilizer elements.

INRA research carried intensive molecular study through characterization of SSR type molecular markers allowing the identification of reference varieties (Mejhoul, Boufeggous, Bouzekri, Najda, Aziza, Boufeggous-Aghrass and 2 males) as well as Sequencing and assembly of the draft genome of *Fusarium oxysporum* F sp. *albedinis* (Khay et al., 2020). The later authors reported the genome assembly of the Foa 133 strain, which consists of 3,325 contigs with a total length of 56,228,901 bp, a GC content of 47.42%, an N50 value of 131,587 bp, and 3,684 predicted genes. The circular mitogenome of isolate Foa44 is 51,601 bp in length and contains 26 transfer RNA (tRNA) genes, one ribosomal RNA (rRNA), and 28 protein-coding genes (Khay et al., 2021). In addition to disease resistant cultivars, proper date palm cultivation requires, pruning, pollination, fruit thinning, bunch removal and fruit harvesting, are highly essential for good quality fruit production (Noutfia et al., 2021) and post-harvest processing (Harrak, 2022). Still, the main barrier to higher and stable date productivity and quality is pollination which is essential for using these genetic improvements. In this regards, researchers have tried to mechanized the practice and recently to use advanced digital technologies such as drones.

## 2.2. Irrigation management for rational and efficient use of water resources

Drought, a recurring phenomenon with major impacts on both human and natural systems, is the most widespread climatic extreme that negatively affects the oasis ecosystems. Although irrigation has been widely practiced for thousands of years, still drought, salinity and Bayoud are leading to permanently damaged ecosystems and widespread degradation of soils and biodiversity. Thus, the different possible scenarios by the year 2050 showed that the rainfall regime would tend to decrease while temperatures and evaporation will experience a certain increase (Verner et al., 2018).

The irrigation of the date palm, and of the agroforestry linked to it, constitutes a fundamental pillar in its technical management. However, although saving water is a priority for government, rural and agricultural development agencies and irrigation scheme managers, it is not usually a priority for farmers who are more worried about saving money and maximizing profits. Irrigating farmers are often more concerned about the costs of irrigation, the financial benefits of crop yield and quality, and

resilience to water scarcity. Consequently, adaptation pathways to raise agricultural incomes and productivity could focus on improving water use efficiency by cropping systems and hence shifting to ensure resilience through modern and smart irrigation and water harvesting options that are more durable and economic and socially acceptable. The annual water requirement of palm crops is a function of tree age, variety, season, planting density, water salinity and soil type. For good tree productivity, irrigation water must be sufficient without being excessive. According to Sabri (2016), the water requirements of young plantations of the Najda variety, during the first eight years of plantation, increased according to their age. Indeed, during the first year, the plants need about  $2 \text{ m}^3 / \text{plant} / \text{year}$ , for a total of  $246 \text{ m}^3 / \text{ha} / \text{year}$ . This volume has evolved significantly depending on the growth and development of the palm trees to reach more than  $38 \text{ m}^3 / \text{year}$  in the eighth year, or the equivalent of  $5324 \text{ m}^3 / \text{ha} / \text{year}$ .

Bourziza et al. (2017) found that (i) water savings is around 15% using subsurface drip irrigation compared to surface drip irrigation, (ii) subsurface drip irrigation reduces losses by direct evaporation, runoff and deep percolation, (iii) subsurface drip irrigation promotes better development of the root system and growth of the palms, guaranteeing improved yield and water use efficiency and (iv) the subsurface drip irrigation allows for better control and distribution of water across the soil profile and therefore the date palm can use almost all of the water delivered. In another study, Controlled deficit irrigation allows more efficient use of irrigation water by the date palm, contributes to the rationalization of water inputs and therefore to the sustainability of the oases (Sabri et al., 2017a).

Precision irrigation guarantees a homogenous development of palm plants, while saving water and fertilizers and allow higher yield and quality of dates (case of Mejhoul variety by Sabri et al., 2017b). However, for better rooting (formation of pivoting and lateral roots necessary to hold the plants), it is advisable to irrigate the palm trees using surface irrigation during the first months after planting, then by the "drip" irrigation methods.

Precision irrigation promotes better water use, increase land-use intensity, and make labor resources more productive. However, without financial supports and subsidies, small-scale farmers have fewer options. Such supports make these actions more effective at long-term to

improve yields and quality of products and stabilize agricultural incomes. Other actions to be taken include: improving technology and knowledge access, improving pests and disease management, and establishing better value chains and marketing systems for date palm and crops within oasis ecosystems. Among pertinent actions underground, the project on Adaptation to Climate Change in Oasis Zones (PACCZO) which consists of the rehabilitation of ancestral irrigation systems, the establishment of new irrigation structures and the support of local initiatives for the benefit of young people and women in agriculture, tourism and handicrafts (MAPMDREF, 2022c).

### 2.3. Date palm ecosystem health

Host plant resistance, though constituting the first line of defense against bayoud, is not yet developed for other diseases and pests in date palm production systems. According to Essarioui et al. (2018), «Bayoud», a vascular wilt disease, has become for more than a century a serious threat to date palm in Moroccan oases. This epidemic has wiped out a wide range of cultivars that were highly appreciated by growers, leading to an impoverishment in palm genetic diversity and a decrease in farmer's income. Most of high value commercial varieties, such as "Mejhool" and "Bouffegous", are highly sensitive and require intensive management against the pathogen. Thus developing appropriate anticipative and integrated management strategies to best control the disease was the major objective of recent research and development projects. In addition, it is highly recommended to avoid planting crops recognized as healthy carriers (Henna, Lucerne and Alfalfa) from contaminated palm groves.

Essarioui et al. (2018) reported that early detection is one of the major challenges in any strategy to combat incurable plant diseases like Bayoud. Early detection using molecular techniques using Polymerase Chain Reaction (PCR) allows for rapid eradication or containment strategies, thus reducing economic losses and environmental effects. In addition, advancing in knowledge of the current geographical distribution of Bayoud is a key element that provide more visibility on the dynamics of the potential evolution of the disease and the strategy to be applied to prevent its spread. As claimed by these authors and supported by Mrabet et al. (2020), field surveys and analyzes of suspect vegetation coupled with the use of GIS and satellite images can constitute

fundamental tools in the actions of geographical delimitation and containment of the Bayoud. Bouhssini and Faleiro (2018) called for the implementation of climate resilient pest and disease management programs. The protection of the Moroccan oases from Bayoud infestation requires an integrated approach that takes into consideration the geographical distribution of the disease as an indicator of the level of risk, the deployment of new resistant varieties as a measure of limitation and containment of populations of the pathogen, and the adoption of early detection techniques for possible timely intervention in the event of the appearance of new outbreaks (Essarioui et al., 2018). Essarioui and Sedra (2010; 2017) developed a soil disinfection technique by combining solarization and fumigation in the event of the introduction of the disease in newly planted areas. In other hand, the use of natural biocidal products can reinforce this strategy. Bouhlali et al. (2020) explored the potential of using bioactive plant products in the management of bayoud and are developing and implementing a compost-based biological approach. Some antagonistic bacteria, actinomyceta and fungi, that have been isolated from date palm rhizosphere and from suppressive soils, have been able to inhibit the development of the pathogen in vitro, in soil and in vivo under glass house on young palm plans. The examples of antagonistic microorganisms are: for bacteria: *Pseudomonas fluorescent*, *Pseudomonas sp* and *Bacillus sp.*, for fungi: *Stachybotrys sp.*, *Fusarium oxysporum*, *Fusarium sp.* *Gliocladium sp.*, *Rhizoctonia sp.*, *Penicillium sp.* and *Trichoderma sp.* Detailed measures for managing bayoud in contaminated and free bayoud zones were presented by Sedra (2018). But, according to Bouhssini and Faleiro (2018), the integrated pest management (IPM) program on date palm should be based on real, field-specific situations and feasible solutions.

#### 2.4. Rethinking livestock management

The livelihoods and food security of oasis people are directly linked and dependent of livestock (Bouaziz et al., 2017). In fact, in these fragile systems, livestock and livestock-feed production are indispensable to economic and social stability of resource poor farmers and pastoralists (Alary et al., 2022). Paradoxically, livestock growth has generated unbalanced environmental impact on land and biodiversity leading to excessive desertification (mainly due to overgrazing). It is worth saying that oasis

based livestock and grazing systems tend to be closed systems where the waste products of one production cycle (manure and plant residues) are used as inputs to another cycle (Srairi et al., 2017). Srairi et al. (2017) point out, for the oases of the Draa Valley (Morocco), a beginning of livestock specialization, in particular the intensification of sheep production, centered around the selection of the D'man breed, and the intensification of cattle breeding. However, these two strategies are proving to be quite risky and poorly performing. The authors therefore plead for taking into account the diversity of types of livestock farming in order to better exploit local resources, including pastoral ones, in a highly constrained natural environment. In other terms, the sustainability of oasis is highly dependent on reducing the environmental footprint of livestock and pastoral systems and on establishing sustainable food and feed production.

Research studies have been conducted on performances and reproduction of small ruminants, D'man sheep and Draa Goat breeds, globally known for their prolificacy, or the roles of the dromedary as this species is often reared in rangelands around the oasis, contributing to the supply of high quality milk and meat (Faye et al., 2017; Ibbelbachyr et al., 2014).

### 3. DIGITAL OASIS FOR IMPROVED ACCESS TO KNOWLEDGE AND DISRUPTIVE SOLUTIONS

The Saharan agricultural zone extends over vast territories totaling an area of 471,000 km<sup>2</sup>, i.e. two-thirds of the country, comprising 11 provinces: Errachidia, Ouarzazate, Tata, Tiznit, Guelmim, Tantan, Figuig, Laayoun, Smara, Boujdour and Oued Eddahab. The region of Tafilalet, in the south of the country, is home to the largest oasis in the world. To achieve its objectives of modernizing the date palm sector and intensifying date production, the government subsidizes the creation of new plantations. Hence, twenty thousands of hectares of date palms have been planted and large modern projects have emerged in areas outside, but close to, traditional oases.

A lack of geo-referenced information (GPS readings) in field surveys is one of the major limitations for managing palm groves and developing risk analysis at spatio-temporal scales. Hence, a 6-year project bringing together INRA, ANDZOA and regional representatives of department of agriculture was approved out to

carry census, characterization and mapping of palm groves in Morocco. The specific objectives were (i) Counting of plants and mapping of planting densities; (ii) Delimitation of areas at potential risk of Bayoud by spatial remote sensing; (iii) Delimitation and monitoring of extension areas in modern palm groves; (iv) Development of a geographical database " and web- based "GIS-Palm". From this study, it was found that the date palms cover an area of 59 600 hectares and represent 6.9 million trees. In addition, the palm date area was digitized and embedded in a georeferenced numerical platform for use by producers, professionals and government institutions (Mrabet et al., 2020). This will allow better access to the knowledge needed by development agents, researchers, policy makers, and other stakeholders at the right time for a better integration of the several management solutions and practices needed to improve ecosystem sustainability and productivity. In addition, the project has the other relatable objective to open access to applications of Big Data, artificial intelligence and other cutting-edge technologies in order to fully understand the challenges and transformations across time and scales within the oasis ecosystems and communities.

#### **4. CONCLUSIONS AND RECOMMENDATION FOR EQUITABLE RECOVERY**

In the midst of exceptional uncertainty, policy makers are grappling with the delicate task of scaling back the degradation of oasis ecosystems while encouraging creation of the conditions needed to restore economic activity and growth (i.e. Sustainable Oasis Initiative). In this regard, the chapter focuses on the interrelated social and economic risks that households, businesses, development institutions and government are facing as a consequence of the on-going oasis ecosystem degradation and recurrent crisis. The unfolding climate crisis has already led to alarming levels of water security and poverty rates have soared and inequality has widened both across and within communities. It offers new insights from research and innovation projects carried during the last few decades. While the practice of agroforestry-based production system in the traditional oasis offers opportunities for sustainability, intensive production coupled with cultivar genetic uniformity increase vulnerability to diseases caused by plant pathogens and especially the causal agent of Bayoud disease.

Morocco has expanded palm date production, initiated new plantings, and expanded irrigation access to support the sector's commercialization, but as in the cases of most crops, it remains vulnerable to disease, drought and climate change. By taking steps now to improve cultivation techniques and reduce climate vulnerability for small-scale landholders, which comprise the majority of date producers, Morocco will be better positioned to meet its output and export targets and retain its protruding position in Arab and international markets.

Bayoud control should be based on the combination and integration of many approaches, including early detection, prophylactic measures, cultural practices, use of natural biocidal products, knowledge of spatial distribution and intensive management of the pathogen's populations in order to prevent its growth and establishment.

Lastly, in order to achieve the objectives of securing food, environment and ecosystems in the oasis contexts, the following should be enabled:

- Promoting transparent and accountable governance with durable and trust transition to green/circular economy and well-being,
- Reducing gaps, leveraging challenges and identifying pathways to enhance the availability, access and use of technology in agriculture in the oasis and enforce actions and measure for transforming the agri-food systems to be healthier and sustainable;
- Finding pathways and encouraging policies to enhance private sector's role in ensuring food, energy and water nexus.

This is in purpose of advancing achievements to sustainable food supply chains, access to healthy diets, food safety, nutrition education, gender equality, and resilient food systems. In addition, and especially in fragile and turbulent ecosystems like oasis, developing, adopting and scaling up of innovation involves better understanding of impact pathways, risks and benefits of technologies by the stakeholders and decision-makers and to develop new partnership and business models that include the public and private sectors, civil society and farmer organizations.

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