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Government Policies, Financial Scopes and Technological Usages for Agricultural Development and Post-Harvest Loss Reduction in Algeria

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Abstract

Agriculture is considered to be a vital aspect of Algeria's national economy and rural development. Achieving sustainable agricultural production, generating employment, reducing imports and minimising post-harvest crops losses are the major objectives of the Algerian government. However, based on the evaluation of existing policies, this study found that poor governance is hampering the agriculture sector, particularly in terms of management of financial resources, where most financial investments are made only for short-term gains. The lack of awareness about the importance of post-harvest practices and lack of using modern technology threaten the growth of this sector. Adopting sound post-harvest methods can reduce food losses and wastage in every stage of the food supply chain, and integration of modern techniques, skilled labour, and education training systems are very important if agriculture in Algeria is to progress.

Keywords: *Algeria; Agriculture; Post-Harvest; Technology Adoption; Credit Agricole; Development; Government spending; Agro-technology; Agro-finance*

1. Introduction

Ensuring food security for a growing population is one of the major challenges of the world. According to FAO estimations, the world's population is expected to be 9.2 billion by 2050, when farmers are expected to produce twice as much food as they do today in order to feed this growing population. This rapid increase in the world's population is being accompanied with environmental degradation and climate change that have raised the spectre of having food security in many countries. Therefore, with reference to food security, improving agricultural technology and reducing post-harvest loss are very important options to ensure food security.

Agriculture plays a crucial role in Algeria's rural development and is considered to be an important part of the national economy. The Agriculture Development Plan implemented in 2000 by the Ministry of Agriculture has improved the sector's productivity and contributed to better production outcomes. In the 2000s the agriculture sector improved its position in GDP continuously, growing faster than the non-hydrocarbon industries and almost as much as the building and public works sectors. Beyond the sector's share of GDP, agriculture has been the driving force of the country's economic growth. During the period 2004-2014, the sector experienced an annual growth rate of 7.06%, whereas during the same period this rate was only 2.72% for the whole of the economy.

Furthermore, agriculture contributed approximately 12.27% to the GDP (World Bank, 2018). The agri-foods generated 19% of added value to agriculture, which accounts for almost 50% of the sector's non-hydrocarbon industrial added value. Referring to employment, agriculture's share declined from 22.5% to 12.7% between 1995 and 2016, and then again by 12% in 2018 (Ministry of Agriculture and Rural Development, 2018). This severe employment crisis was due to the lack of skilled workers and young wage-earners on the farms, coupled by the lack of entrepreneurial skills that Algerian farmers had. The poor standard of living in Algeria generally simply led to the low level of the agriculture industry, low wages and lack of social legislation on improving working conditions that have made working on the land undesirable.

Besides the employment crisis, Algeria's agricultural performance has been hampered by constraints on imports since 2016. However, according to the National Office of Statistics

(NOS) the sector's value added grew by only 1.8% in 2016, down from 6% in 2015. In addition, the decline in hydrocarbons revenues in 2014 have shrunk foreign currency reserves, resulting in the government tightening on imports but also as a consequence, food imports. In early 2017, the government proceeded to increase the value added tax (VAT) applied to some cereals and animal feed products from 7% to 9%. Cereal imports fell from \$2.13bn in 2016 to \$2.11bn by the end of September 2017. Moreover, the government announced that it planned to cut the total import bill from \$41bn at the end of 2017 to \$30bn in 2018 (Bessaoud et al., 2019).

Despite the government's efforts to curtail the size of imports coming into Algeria and to increase agricultural output, this means fostering collaboration between farmers and the processing industry; yet the road to food security is still long. Food self-sufficiency is still a critical issue for the stability and independence of the country. In modern economies, the application and promotion of numerous national research programs, in particular those relating to the fields of agriculture and water resources, remain weak and limited in their impact. This lack of scientific research applications is due to too much work not leaving the research laboratories and calls into question what the higher education institutions in Algeria are trying to achieve (Bessaoud et al., 2019).

Bellout et al. (2020) indicated that suitable research technologies which promote food security are an essential priority for many developing countries including Algeria. In order to be successful, these technologies must be presented and taught to farmers through modern education teaching/training methods and strategies. For an example, the region of El Oued is considered an important area for potato production in Algeria. With its 33,000 hectares the region has become the largest potato production area in the country. However, potato production is still experiencing some problems in terms of irrigation, fertilisation, pesticides applications, the quality of material and prevention of post-harvest losses. Today, the potato harvest is based on using hand harvesting methods. For workers, the process takes about thirty employees two days to complete at a cost of \$ 736 / ha (Nieuwsbericht, 2016). However, this practice is expensive, slow, produces injured tubers which in turn cause bacterial and fungal diseases especially during harvesting when spade forks are employed but damage the tubers. Added to this, storage practices cause huge post-harvest losses as a consequence of improper storage technologies associated with poor farming practices. In El Oued no substantial storage facilities are available, so the potatoes are stored in sacs awaiting transporting to the market. This study investigates how government policies, financing facilities and technological usage for agriculture are all affecting the post-harvest scenario in Algeria.

This study selects Algeria for analysis because its agricultural sector plays a crucial role in providing food, raw materials and employment opportunities, despite the fact that the Algerian economy heavily relies on hydrocarbon exports. Improving the agricultural sector will help diversify the economy so that the effects of oil price fluctuations can be offset (Fahsi & Chibi, 2019). Moreover, the growing needs generated by a growing population are evident, given that it reached more than 41 million in 2017. The issue of food security is now all important since the population of Algeria is expected to increase to 50 million in 2030 and 70 million in 2050 (Bessaoud et al., 2019). For this reason, the sustainable development of the agriculture sector and reduction of post-harvest losses is critical if food is to be available in Algeria in enough quantities.

2. An Overview of Algeria's Agriculture and Post-Harvest scenario

In the Mediterranean region, food systems are experiencing multiple challenges concerning the consumption and production processes. Food insecurity and malnutrition and are still present in some countries in the region (Arous et al., 2017). The current slump in the cereals sector does

not only lie in low yields but also in the loss of considerable quantities of production due to various causes. For example the harvest period there are delays, leading to the cereals being left to an "overripe" stage. Here the ears of the plant are more vulnerable during the cutting phase, in addition to damage to the crop caused by substandard harvesting equipment and non-healthy post-harvest storage conditions. According to one former Minister of Agriculture, he indicated that the storage capacity does not exceed 31 million quintals while the quintals produced were 60 million in 2018 (Manseur, 2019). In addition, most of the available silos do not meet the required standards in terms of temperature, humidity control, etc. The delay in storage building projects and ineffective agriculture policies represent an obstacle for the development of the sector. The willingness to build 39 storage structures, including 9 metal silos and 30 concrete silos at a total cost of \$558 million, has not been attended to now for at least 10 years. Only two concrete silos have been approved, one in Bouchgouf, in the wilaya of Guelma with a capacity of 30,000 t, while the other is in El Khroub, in the wilaya of Constantine, with a capacity of 50,000 t (Khris, 2017).

The Mediterranean region's climate is characterised by a long period of drought during the summer and a large variability of rainfalls. These constraints limit severely the prospects of successfully intensified agriculture and strongly differentiated agricultural spaces. In Algeria, problem of constantly degraded soils and ecosystems has caused the desertification of vulnerable areas. Moreover, about 600 million m³ of untreated waste are discharged annually, affecting soils and the safety of drinking or using water resources. This factor was considered as the most important challenge for water and environment management authorities in Algeria (Ferrah & Oubelli, 2013). Post-harvest losses in Algeria represent a major threat to the food security and livelihoods of people, in which food storage constitutes the main problem and this is due many isolated places not being connected to electricity or power sources. Financial obstacles act in such a way to generate only low investment in energy sources.

Jbilou et al. (2018) suggested to design at an affordable price a system including a photovoltaic system able to supply an ozone generator to help disinfect food storage rooms in isolated areas. These authors carried an experimental study using several vegetables and fruits (VF) that were placed in an ozone-treated room. Results show that the system made long-term storage with minimal energy consumption possible. They concluded that ozone is very important and helps to increase the shelf life of food products. Another recent study conducted by Iddir (2019) looked at the impact of maturity, altitude and storage time on the quality of olive oil. The results revealed after a storage period lasting 12 months, the influence of the two parameters - altitude, maturation and their interactions - was significant ($P \leq 0,05$) on the main quality criteria of olive oil: acidity, peroxide index, the pigment content (carotenoids and chlorophyll), content of total phenolic compounds and acids' profiles.

In their analysis, Marouf and Khali (2019) studied the effect of Polyethylene terephthalate (PET) packaging on the post-harvest physiology of Deglet-Nour dates under different storage conditions ($22^{\circ}\text{C} \pm 1^{\circ}\text{C}$ and 75-80% RH, $10^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and 85-90% RH) in Algeria. They used an experimental set-up consisting of a box with dimensions of $7.5 \times 15.00 \times 7.5$ cm. They found that PET packaging limited the respiratory intensity during storage, and they concluded that the combination of thermisation-packaging and cold storage ($10^{\circ}\text{C} \pm 2^{\circ}\text{C}$) is an excellent storage method. It ensures an optimal physiological basis for dates by limiting their respiratory activity. Moreover, another important obstacle that affects post-harvest conditions in Algeria is the level of technology employed. Compared to other countries, technology in Algeria is basically obsolete and operated along traditional lines that are not economical. A study by Messaoudi and Touahar (2019) proposed a solution involving proper technological planning of agro-food products and to compare the traditional method of pollination with more technology-driven palm tree growing in Algeria. They found that the technological method is the most effective.

Referring to the harvesting phase these authors found that mechanical cranes facilitate harvesting the product as more effective than people climbing up the palm tree. As well, the authors simulated a production process using a classic model and a technological model, and they concluded that the latter made it possible to obtain high quality fruits and in high quantity that could supply the national and international markets throughout the year.

3. Policy Reform of the Agriculture Sector in Algeria

In Algeria, several agriculture-related policies were implemented following independence in 1962. The general objective of these policies was to boost agricultural development and to consolidate food security throughout the country. These policy phases are explained in more detail below.

3.1 Autogestion Policy 1962-1970

Most of the fertile farmlands after independence were combined and transformed into a large, self-managed area called Autogestion. These farms were characterised by a strong disparity in the production, distribution of land, and by unequal participation in the economy. This part of the self-managed sector covered more than 2.5 million hectares of former colonial lands and included some 2,200 public farms. Their operations were based on mechanisation and chemical fertilisers (Ageron, 1991).

3.2 Agrarian Revolution Policy 1971-1979

The government expropriated large private holdings and redistributed the land to poor households and farmers (Aghrout & Redha, 2004). All the facilities and resources of production, equipment and investments were employed according to the socialist, centralised economic policy directives. As for the private sector, it continued to be marginalised and discouraged from operating (Bourdenane, 1991). However, due to the lack of incentives in the cooperative sector to increase production and the absence of innovation and training (Clever, 1982), the socialist economic policy produced an agriculture industry characterised by poor productivity and equally poor efficiency.

3.3 Initial Transition to Market Economy 1980-1986

The division of the agricultural sector and the absence of a coherent agricultural policy led to a stagnation in agricultural production (Laoubi & Yamao, 2012). However, Algeria's increased dependence on agricultural imports pushed the government to encourage and promote private land ownership and the merging of self-managed agricultural units. As well, the government reformed agrarian cooperatives into a single state sector with the aim of establishing a controllable production unit (Aghrout & Redha, 2004). Consequently, these processes were accompanied by support measures such as increasing producers' prices, credit facilities and access to subsidised capital. This period marks the beginning of the transition to a market economy and the gradual removal of the state from economic policies.

3.4 Economic Crisis 1987-1999

Algeria began to take important steps for the economic transformation of the agricultural sector. A higher percentage of public funds was allocated to the agriculture sector, particularly water projects and this period was marked by the liberalization of the agricultural market. In 1988, the decree allowed private farmers to purchase inputs from any suppliers. As April 1991, the government allowed individuals and farm cooperatives to engage in wholesale trading in

agricultural inputs. Hence, this period was noted as one experiencing a significant drop in investment, low mechanisation, a sharp decline in purchases of agricultural consumables, in particular fertilisers and pesticides, the rise of illegal practices and the expansion of speculative farming (Laoubi & Yamao, 2012).

3.5 Agriculture in the State Budget

Government expenditures on the agriculture sector improved by 1.26% during 1995-2013 (International Food Policy Research Institute, 2016). Moreover, it accounted for 18.63% of GDP in 2013 compared to 7.70% in 1995. This comparative advantage can be explained by two reasons. For the first, the importation of sugar was tax-free and there were no customs duties in the framework concerning the agreements made with the European Union and national subsidies granted to energy production. In addition, financing of the various development plans of the sector during 2000-2015 required an overall budget of US\$13 billion, broken down into US\$3 billion in the capital budget and US\$10 billion in the funds (see Table 1 in Appendix A). Consumption amounted to a total of US\$11 billion, divided into US\$3 billion under the capital budget and US\$8 billion under the funds (Bessaoud et al., 2019).

Table 1: Agricultural budget during the 2000-2015 period (in Billions of US Dollars)

	Endowment global	Annual average	Consumption	Annual average
Capital budget	3	15.98	3	12.26
Endowment fund	10	49.09	8	36.31
Total	13	65.08	11	46.57

Source: CREAD, 2018

For the period 2000-2010, a total of almost US\$17 365 million was granted for the budget operated by the Ministry of Agriculture and Rural Development (Table 2). The direct support to farms and farmers' incomes amounted to US\$6622 million throughout the period, which is lower than the amount spent on protecting the purchasing power of consumers valued at US\$ 6676 million. The rest of the budget was shared between the capital expenditure on public sector organisations and the operating expenses (Bessaoud et al., 2019).

Table 2: Change in budgets of MADR during the 2000 – 2010 period (in Millions of US Dollars)

Year	Equipment	Operation	Support for exploitation	Support for purchasing power	Total
2000	135	95	486	-	716
2001	162	108	338	-	608
2002	149	108	365	-	622
2003	122	122	676	-	919
2004	149	122	757	-	1027
2005	149	122	757	-	1027
2006	649	135	811	149	1743
2007	176	162	622	149	1108
2008	122	243	986	2486	3838
2009	230	243	230	2595	3297

2010	284	284	595	1297	2459
Total	2324	1743	6622	6676	17365

Source : Ministry of Agriculture and Rural Development, 2018

A review of the finance laws over the period 2008-2019 shows that credit of payment oriented to agricultural and hydropower accounted for an annual average of 12.4% of the total capital budget between 2008 and 2012. This has demonstrated the Algerian government's interest in these two sectors of the economy. In 2013 payment credits granted to the two sectors fell to 5.1%. Moreover, it dropped to an annual average of 6.7% over the five-year period 2014-2019 (see Table 3).

Table 3: Credit payments to the agriculture-hydraulic sector during the 2008–2019 period (in Millions of US Dollars)

Year	Credit payments	Total budget equipment	Percentage of agriculture-hydraulic
2008	4828	36000	13.41
2009	5472	36069	15.15
2010	4541	40838	11.1
2011	5444	44222	12.32
2012	3909	36623	10.6
2013	1633	32203	5,1
2014	2550	36763	6.91
2015	3160	38763	8.13
2016	2486	29147	8.54
2017	1382	20827	6.61
2018	1362	34853	3.9
2019	1983	30261	6.6

Source: Ministry of Finance, 2019

Other measures taken so far include support for producers' prices, incentives for intensification through increased use of production equipment and sources (water, fertilisers, machines, irrigation equipment, etc.) as part of the sector's financial development and to ensure the effective reclamation of land. The adoption of the National Agricultural Development Program (PNDA). allowed the government to make large investments in agriculture.

4. Financing Programs for Agricultural and Post-harvest Development

Until 2000, political priority was given to Algerian heavy industries at the expense of agriculture and the food sector. Moreover, the strong growth in population favoured and amplified Algeria's food dependence, which pushed the Algerian government to launch a financing program to sustain agriculture, support farm producers and reduce dependence on imports.

4.1 The National Program for the Development of Agriculture (PNDA)

As part of the program to support economic recovery from 2001-2004, PNDA was focused on consolidating the agriculture sector and for it to achieve an annual growth rate of 10% (Ministère de l'Agriculture, de L'agronomie et de la Foret, 2014). Moreover, the goal was to ensure the country's food security, promote better incomes and employment. Based on the constraints faced by the agriculture industry, the PNDA appeared to promote sustainable

development of agriculture so that all projects were economically feasible, socially acceptable and environmentally friendly (Laoubi et al., 2010). Agriculture registered a significant increase of 6.5% on average, since the start of the PNDA's implementation in 2000, while the growth rate between 1990 and 2000 was only 4%. Moreover, the total investment under the PNDA plan amounted to US\$4 billion, representing an annual average of \$578 million and an estimated investment of 62 dollar per ha/year between 2000 and 2006. This figure contrasted to the government aid offered to European farmers through the EU, where it was estimated to be more than 266 dollars per ha/year, four times more than the aid provided to Algerian farmers (Bessaoud et al., 2019). However, this policy suffered from an absence of transparency and equity when state aid was given to different groups in Algeria. Furthermore the lack of credit, limited access to inputs, ownership constraints, lack of investment, water availability, education or skills of farmers and lack of training, poorly managed marketing channels, bureaucracy, and slowness of agreement processes proved to be serious problems when this program was being applied.

4.2 The National Program for Agriculture and Rural Development (PNDAR)

The PNDAR scheme was designed in order to solve the existing challenges and constraints affecting Algerian society (Ministry of Agriculture and Rural Development, 2007) that were responsible for the degradation of natural resources, food security issues, and diminishing social peace and order particularly in Algeria's rural areas (Akerkar, 2015). Total investment provided to this program under the Support Plan for Economic Recovery (PSRE) in the period (2001-2004) amounted to \$1.7 billion, while it was \$7.1 billion under the Complementary Plan for Economic Growth Support (PCSC) during the period 2005-2009. These amounts targeted the agriculture sector (Laoubi & Yamao, 2012).

4.3 The Agricultural and Rural Renewal Policy (ARRP)

In the year 2008 the various plans were redeveloped to constitute one overarching plan known as the Agricultural and Rural Policy (ARRP), and assigned to the Ministry of Agriculture and Rural Development to implement and oversee. This policy focused on strengthening national food security, reducing vulnerabilities as part of a public-private partnership and involving various actors (Bessaoud et al., 2019). The policy was based on three complementary pillars, these being agricultural renewal, rural renewal and what was known as the Human Capacity Building and Support Program Technical Producers (PRCHAT).

4.4 The Felaha Plan 2019

The Felaha Plan of 2019 had the goal of creating integrated farm models based on an intensive production system with storage, processing, and recovery of agricultural produce. It set out to provide for the creation of 350 large integrated farms funded by land grants that to this day are tens of thousands of hectares in size.

4.5 Agricultural Funding

Funding the agriculture sector through bank credit was part of the economic structure of agricultural production. The Algerian government launched a bank credit scheme to help and encourage farmers to improve national productivity (Boubekeur, 2016). The agriculture sector used the following sources of finance: The National Bank of Algeria, the Bank of Agriculture and Rural Development (BADR), National Agricultural Mutual Fund (CNMA), Corporate and Investment Bank (CIB), The National Fund of Regulation and Development of Agriculture (FNRDA) and microcredit schemes.

5. Agricultural and Post-harvest Technological Development in Algeria

Since the launch of a national agricultural development program, agriculture has made an appreciable progress in terms of technology that has improved output and post-harvest processes. Measures concerning the modernisation and upgrading of farms with investment subsidies has made the acquisition of agricultural equipment and machinery possible, the availability of seeds, the granting of credit, improved rates of interest on loans and continuous advice for improving technical methods (Lamani & Ilbert, 2016). According to Bouzid et al. (2020) the level of innovation in farming techniques is perceivable, for example the introduction of plant protection products and machines and planting techniques by potato farmers. Other enhancements include the adoption of crop rotation and substances to destroy weeds. Moreover, farmers in the south of Algeria have applied post-harvest treatment in the form of a solar drying process that has led to a high quality of Algerian Deglet-Nour dates being produced. This method as good advantages especially in storage where temperature and microbiological degradation can be controlled, owing to low cost and green energy features (Mennouche et al., 2017).

Due to Algeria always being at the mercy of water scarcity, the need to manage water demand is crucial. So investment in Water Saving Technologies (WST) was promoted in order to use less water in agriculture and all related processes. According to Oulmane and Benmehala (2019) water productivity has increased by adding inputs including labour and fertilisers but is negatively correlated to water quantity. The authors stated that using WST can enhance crop water allocation and affect the crop yield and water productivity in positive ways. Today, the agriculture sector needs to adapt to irrigation problems, and new technologies can reduce water loss and enhance water productivity (Sanz, 1999; Evans & Sadler, 2008). The new technologies and the opportunities offered by the advent of 'intelligent agriculture' constitute a crucial tool for boosting the development of Algerian agriculture and meeting the needs of a rapidly growing population. In fact, smart agriculture is the key strategy to achieve food security and the emergence of ecological agriculture provides healthy products of good nutritional quality. The concept of intelligent agriculture has been workshopped by the Filaha Foundation and Filaha Innove which bring together experts and multidisciplinary skills who can advise farmers on new technologies in agriculture. Today, the adoption of a new technology in agriculture is more critically important than in other sectors because farmers still prefer to use more traditional methods which slows down productivity.

The post-harvest scenario in Algeria is not yet fully developed. The storage process is still being devised so that it works efficiently, and the packaging process is mostly simple, while the cooling of agricultural products is still largely hit and miss. Nonetheless the opportunities are there to improve the products' quality, and especially for the post-harvest storage process in Algeria. Most of the dates produced in Algeria are stored in refrigeration for the national market but there is still a 10-20% loss caused by insect infestation (*Ectomyelois ceratoniae*). Moreover, the prospects of applying innovative solar technologies in post-harvest operations such as ripening, heat treatments for disease and insect control and drying fumigation are still being researched (Benkeblia, 2000).

Poor post-harvest and agronomic practices in Algeria have influenced the levels of agricultural loss. Farmers using innovative technologies and methods is the key to improving productivity, lifting incomes and reducing post-harvest losses. This approach will allow farmers to adapt to climate change, manage inputs better, increase their yields and improve the quality of their crops. In order to improve agriculture output, Algeria's best prospects lie in biotechnology. A genetics-based strategy will help improve crop yields and to increase the resilience of future

crops against multiple biotic and abiotic stresses, which will have good implications for animal health, seed, healthy plants, biofuel production and promotion of bioenergy (Ferrah & Oubelli, 2013). According to the director of studies at the National Institute for Agricultural Extension of Algiers, Mohamed Abdelmotalib, the exploitation of ICT by farmers is currently very low and a good information campaign must be directed at farmer to convince them of their importance. Moreover, the Ministry of Post, Telecommunications Technology and Digital Technology is now involved in the implementation of a reliable computer system that allows the development of electronic services that help agriculture.

6. Discussions and Policy Recommendations

The agriculture sector is an extremely important sector of the national economy, and for that the Algerian government has developed various policies and rural development programs. Moreover, these policies incorporated various modes of financing involving the banking sector, financing of industrial and commercial activities and various investment and operating credits to farmers, breeders and economic enterprises. However, and despite the huge investment made, these policies and successive agricultural development plans have produced only meager results considering the country's potential and needs. Currently, Algerian agriculture suffers from several problems such as being non-competitive, poor integration into foreign markets and the usage of inefficient post-harvest methods. As well, bureaucratic hindrances and practices make it difficult to adapt technological, business and/or marketing innovations, so more needs to be done for funding research. Moreover, the status of food security in Algeria continues to face several challenges and constraints (climatic, natural, and technical, etc.).

Despite the financial aid given to the post-harvest sector and technology innovation under the country's current agricultural plans, the post-harvest process in Algeria is still modest and mainly focused on its cereals and potatoes. Post-harvest practices are still traditional and time-consuming, characterised by the lack of ventilation and control of CO₂ and humidity. Farmers continue to be stubborn in employing traditional methods during harvest (Messaoudi & Touahar, 2019). The majority of studies have stated the role of technology in making the post-harvest process more efficient and particularly storage in order to reduce food losses. Such studies have encouraged the use of renewable energy to limit the huge consumption of electricity (Elansari & Mostafa, 2020; Liberty et al., 2013; Gustavsson et al., 2011; Chijioke, 2017; Sibanda & Workneh, 2020; Du et al., 2020; Eddine & Fouad, 2010). However, this study found that the post-harvest sector in Algeria is deficient in infrastructure and characterised by low productivity, lack of laboratory research, and inadequate technology compared to other countries. Moreover, findings show that the problems facing the sector were the result of poor governance in the management of investment programs and financial credit schemes.

The post-harvest handling, storage, sorting and packaging contexts in the value-chain are underdeveloped in Algeria (Meijer et al., 2019). However, storage seems to be the main problem the country faces in regard to food products. Poor packaging and climate control techniques during storage have increased the food losses especially in potato which make the product no longer suitable for processing even if potato quality at harvest time is good. Moreover, in Algeria storage of potatoes is carried out for short periods lasting up to 3 months, sometimes 6 months, which is quite different from the Netherlands where potatoes are stored for 8 months and more (Meijer et al., 2019). Potatoes are stored at low temperature with non-forced ventilation and no controls over CO₂ or relative humidity in Algeria. In this regard, a project has been initiated in 2019 by the Netherlands Enterprise Agency and the Netherlands Embassy in Algeria to develop the Algerian food processing industry. Moreover, cooperation between the Algerian Interprofessional Office of Cereals (AIOC) and American Blumberg Grain (ABG) is still in process. It aims to build a horizontal infrastructure for the storage of

high-tech cereals that can contain up to a million tonnes and would help to reduce post-harvest losses from 35% (Aoues et al., 2017) to less than 5%. This will enable the government to make \$US119 million per year. It will also ensure the efficient management of stocks of collected cereals, ensuring a long shelf life and ultimately a healthy and marketable product.

However, due to post-harvest problems, this study recommends policy-makers to subsidise the relevant processes and particularly the storage conditions and quality of essential products and to adapt new technology to reduce food losses and wastage along the food chain. Nowadays, a third of the world's fresh foods are wasted due to their bad storage and transport conditions at improper temperatures (Du et al., 2020). Therefore, new technology will curtail food loss and enable Algeria to maintain a good food security strategy. For example, hermetic storage is one good storage method in developing countries, due to its effectiveness (reducing storage losses to less than 1%) and discouraging the use of dangerous chemicals and pesticides (Kumar, 2017). Post-harvest storage conditions contain different sorts of cooling methods like hydro-cooling, refrigeration, room and vacuum cooling and evaporative cooling systems. However, maintaining good quality fruit and vegetables throughout the food chain process is an indicator of precooling working well.

Today, cooling methods vary and Salamat (2020) found that the integration of post-harvest technology would help to preserve the quality of mushrooms. This integration consists of using forced-air cooling, followed by modified atmosphere packaging and storage in refrigerated conditions. Currently, most countries rely on mechanical vapour compression-based refrigeration driven by diesel in the cold chain (Liu et al., 2012). Subsequently, this technology faces several challenges including poor energy efficiency, high gas emissions and maintenance costs. Furthermore, hydro-cooling can change the rate of microbiological and biochemical changes in products and thereby prevent spoilage and increase the shelf life of certain foods (Gustavsson et al., 2011). In addition, evaporative cooling is found to be an efficient and economical method for storage (Liberty et al., 2013; Chijioke, 2017; Sibanda & Workneh, 2020; Shahzad et al., 2018). The method is very appropriate for farming scenarios because it provides cooling without power sources being required (Chinenye, 2011). On the other hand, Nkolisa (2019) found that a cold room is the best method for cooling followed by evaporative cooler and lastly storage at room temperature.

Coolbot technology has emerged as an appropriate tool that helps small farmers to cool their crops and is used effectively in several countries. The technology is inexpensive and available to all farmers. For the Mediterranean countries Zeer is found to be a suitable, simple solution and a most efficient evaporative cooling system. It costs less than 2 dollars and can store 12 kg of food, keeping them for up to 20 days (Gustafsson & Simson, 2016). Numerical simulations have been devised to improve the precooling performance of fruit and vegetables using advanced mathematical modelling (Duan et al., 2020).

Renewable Energy (RE) particularly solar and wind energy are suitable alternatives to fossil fuels and they represent the largest source of renewable energy supply. RE plays an essential role in the economic development based on its sustainable use and environmentally friendly features. It is also an option to increase productivity and generate better incomes (Senol, 2012), prolong the storage time and maintain freshness of foods and reduce the risk of quality degradation (Du et al., 2020). Power generation, transportation, and heating/cooling are the main three categories of RE (Hasanuzzaman & Kumar, 2020). Wind and solar are in great demand in the agriculture sector, and especially along the food supply chain stages They can provide the necessary energy for powering the fresh produce cold chain (Chaudhari et al., 2015). According to Sontake and Kalamkar (2016) solar energy is the most feasible alternative to fossil fuels. Integrating a solar system with evaporative cooling will enhance cooling and

natural ventilation. According to Sibanda and Workneh (2020) the use of wind and solar energy to power the drying out and isolated areas in Sub-Saharan Africa is non-capital intensive and cheaper than the evaporative cooling system. It has the advantage of generating electricity at any time the wind blows whether day or night through the use of wind turbines.

It is very important to understand that training of farming smallholders is equally as necessary as adopting new technology. This process could help farmers to obtain good knowledge of the post-harvest processes in order to sell good quality products. The good integration of modern techniques, skilled labour and relevant training in modern technology would increase productivity, save time and effort, reduce the required workforce, preserve the quality of the soil and products and generate better incomes. Finance schemes such as microcredit institutions and Credit Agricole should provide training and extension services for farming clients to improve management in agriculture. It is also necessary to shed light on different approaches to make post-harvest food loss assessments and discuss the different existing methodologies, measurements and reporting systems (Kitinojaet et al., 2018).

Information and Communication Technologies (ICT) are another key to success in good agricultural practices. ICT allows a rapid transmission of information, while offering the opportunity to present farmers' concerns about the diseases affecting their crops and livestock, and information on weather warnings that will increase farm efficiency, productivity and profitability, but also forewarn farmers on possible crop losses, protect livelihoods (Hussain, 2016) and providing a cost-effective way to facilitate access to markets (Kamau et al., 2018). Many post-harvest practices require farmers to be in constant touch with local agricultural specialists. A convergence between traditional communication practices and media, such as the internet and the mobile phone, can considerably strengthen the capacity of people to share their experiences and knowledge, to further enhance agriculture and rural development. Indeed, ICT helps to reduce geographic isolation, facilitates dialogue and promotes interactive networks. In Algeria, ICT can change the costs and delivery patterns regarding a wide range of food or meat products and services that farmers provide (Semmar, 2017). It offers a digital exchange method for producers and farmers that will result in lower prices for agricultural products. In addition, the input subsidy systems such as fertilisers should work in such a way to send vouchers directly to farmers' mobile phones (Semmar, 2017). This will make possible in Algeria an efficient distribution of fertilisers, considerable savings and achieve a profitable production target.

7. Conclusions

Improvement in the export sector of any country requires a major improvement in the post-harvest sectors because it helps achieve national income, food self-sufficiency and reduces the need to import things. Today, the current absence of a strong and consistent post-harvest sector in Algeria has hampered any enhancement in productivity and the development of agriculture. Food losses in Algeria are becoming a threat to the livelihoods of many households. Also, the lack of assessment of various public agricultural plans constitutes a major problem where the needs of national agriculture are not properly defined. The poor governance practices and improper management of financial resources makes it difficult to promote the post-harvest sector. Therefore, the agriculture sector will require a strong focus on technology adoption because it is the most effective solution for increasing food availability and security. Also, the presence of good and effective cooperation and communication strategies between government, research, education, industry (private and public) and specialists in post-harvest scenarios will improve people's nutrition. Future investigations should seek to understand the factors influencing the quality characteristics of agriculture products during the post-harvest storage phase. They can also investigate and measure the impact of modern technology in cooling processes for different products during post-harvest storage. Finally, future analyses on

agriculture should combine an assessment of the strengths, weaknesses, opportunities and threats so that agriculture in Algeria becomes sustainable and profitable.

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