Vol. 17(3), pp. 414-424, March, 2021
DOI: 10.5897/AJAR2020.15125
Article Number: 54314B866293
ISSN: 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Review

Water resources and food security in Algeria: Diagnosis and new strategy proposition

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Received 9 August, 2020; Accepted 30 October, 2020

Algeria as an important North African and Mediterranean country with remarkable bioclimatic, edaphic, and political characteristics is under many sorts of negative stress affecting considerably alimentary dependence. Today, Algerian agriculture presents a worrying record. Several warning signs show that the sector is only surviving thanks to massive imports of milk, grains, seeds and chemical fertilizers. The current agricultural model is overtaken by dependence on foreign markets and recourse to costly public subsidies which come exclusively from revenues derived from hydrocarbon exports. Indeed, Algeria is located in region characterized by high water deficit and, poor hydraulic potential, affecting considerably the economy and food security. This situation is more due to mismanagement than an inability to produce enough and healthy food for all Algerians. The current governance is totally inappropriate. The solution mainly involves training, research and technology transfer. In the present perspective paper, we identify with real statistics, organizational, structural, technical, and ecological deficiency causing the suicidal alimentary dependence with alarming repercussion on health and economy. A series of items are proposed to be adopted in order to enable food security in view of available and mobilizable natural resources.

Keywords: Natural resources, water capacity, agricultural production, land management, food security, Algeria.

INTRODUCTION

Every nation around the world still remembers the 2008 food crisis and the social riots that accompanied it, revealing for many countries a structural fragility carrying major systematic risks that make sovereignty and food security a central stake to governance. All this justifies a reflection on the agricultural and food strategies envisaged for the States. Food sovereignty can be understood as "the right of populations, communities and countries to define their own food, agricultural, territorial and work strategy which must be ecologically, socially, economically and culturally adapted. Food sovereignty includes a genuine right to food and food production, which means that all people have the right to healthy, culturally and nutritionally appropriate food, as well as to food production resources and the capacity to sustain their survival life and that of their society.

In the terminology advocated by the World Food Security Council (CFS), food security refers to the

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"physical, social and economic possibility for all human beings, at all times, to obtain sufficient food, healthy and nutritious, allowing them to meet their food needs and preferences to lead a healthy and active life. Food security can take place at different levels, individual or collective. Foods insecure country may have population groups whose food needs are met. And conversely, a country in a food security situation may have social categories whose needs are not met. While the two concepts are complementary, food sovereignty takes on a more political content, notably taking up the idea of a right to food, and the right for any country to implement the best agricultural policies adapted to the needs of its population.

More specifically, the notion of food sovereignty also aims "to promote the return to local agriculture intended primarily to supply local, regional and national markets. According to the alter-globalization movement, local agriculture also offers greater economic, social and environmental efficiency than industrial agriculture and large-scale plantations. Policies aiming at food security and food self-sufficiency in arid countries are mostly based on water resources management in order to promote efficient irrigated agriculture and allowing industrialization of the country.

Good water resource management is considered as condition to reach food security. In a context of pressure on natural resources, water management is central to the development of sustainable production systems. Several avenues are currently being explored to better manage water throughout the production system. Soil, sun and water are considered as almost free resources and factors permeating agricultural production (Vanclay, 2004), hence must be the main policy object of States in development strategies. Since the beginning of the 2000s, the Algerian government has taken important measures to get out of the situation of water scarcity that affected the country. The hydraulic issue has been placed high on the political agenda and big resources have been put in place to mobilize new conventional and unconventional water resources. The new water policy is structured around two strategic axes (Mozas and Ghosn, 2013) The development of hydraulic infrastructure: dams, transfers, seawater desalination plants, purification plants etc.

Institutional reform of the water sector which aims to promote better management of the resource

In the context of food security, Algeria adopted The National Agricultural and Rural Development Plan, giving priorities to the reconversion or adaptation of cropping systems to pedoclimatic conditions. The Algerian policy to improve agricultural production is also based on the development of land, increase of the useful agricultural surface and the reinforcement of investments which still remains poorly supported and thought.

Algeria imported during the last ten years more than 4 million tons of food products, mainly cereals, milk, juices and fruits. The average amount of this bill is about 9 billion USD. The average moisture content of these products fluctuates between 15 and 20%, which represents an average of 600,000 tones. In multiple reports, the World Bank has shown that more than half of the food calories consumed in Algeria are imported. Older studies have also shown that Algeria's food imports are equivalent to 87% billion m^3 of virtual water (Kherbache, 2014). Due to the necessity to evaluate the lack/scarcity of water, more than 150 indicators are employed for measurements (UNESCO WWAP, 2003; Vörösmarty et al., 2005).

Most international institutes interested in analyzing water problems are using water scarcity index commonly expressed by water stress index (Savenije, 2000; Damkjaer and Taylor, 2017). Based on the cited index, a minimum threshold for water satisfaction needs in agricultural, industrial, and energetic sectors is set at 1700 m^3/hab./year. It is also noted that ecosystem stability depends on this index. According to Falkenmark (1997), a country or a region is considered under water stress when annual water availability drops below 1700 m^3/hab. When water supply range from 1000 to 500 m^3/hab/year, the country faces water scarcity (Savenije, 2000; Mekonnen and Hoekstra, 2016), and when water supply is under 500 m^3/hab/year, the country faces absolute scarcity. As a basis of food security program, water resource constituted cornerstone for every strategy in order to ensure self-sufficiency. For decades, Algerian politicians always mentioned strong correlation between water security and food security but no important accomplishment has been done in this way to solve the problem, which generated significant delay in sustainable management of water and food security. No real achievable strategy could succeed without considering water as fundamental factor underlying geographical, social, ecological, and economical vulnerability. Climate changes characterized by significant precipitation decrease estimated between 30 and 40% caused more water problems because of severe drought affecting all regions (Sahnoune et al., 2013; Meddi et al., 2014). It is predicted that the rainfall deficit persists because it depends on known effects of global warming leading to natural scarcity of water (Programme National Exceptionnel, 2011; Bhattarai, 2017; Bouderbala, 2018). The vital role of water characterized by scarcity and shortage constitutes challenges to security of the population and economy which is closely related to health, environmental and, food security in particular (Mohammed and Al-Amin, 2018). "Water and food", "water is a food" or "water makes food" or even "water is food", all these terms make water an essential requirement for sustainable development in the cultural and cultural production of food.

The problem of food security in Algeria in relation to natural resources is rarely studied and documented. The various scientific databases reveal only a few articles that deal much more with water management. In order to elaborate on this diagnosis and solution proposition, we exploited previous statistical studies and data report given by the Algerian authorities in addition to scientific articles, press articles, and experience gained in the field.

The aim of this study is to make a real diagnosis concerning the natural resources allowing sustainable and ecological food security for Algeria. In this paper, several proposals are put forward to help decision-makers understand the value of best natural resources management to guarantee food security.

WATER AVAILABILITY DIAGNOSTIC

Water is so present in our life and around us that we tend to take this precious liquid for granted. It is difficult for us to realize that water is a scarce commodity for many people on this planet. Investigation of data shows that 8 995 hm^3 water is mobilized in Algeria while the real mobilized volume is about 9 125 hm^3 with a difference of about 130 hm^3. The main reason for the observed surplus is due to under-estimation of water demand by small and medium hydraulic stations, and industries (Bouziani, 2006). Mobilized water is exploited at 55% by agriculture, 35% by drinking water supply, and 10% by industries. Algeria is considered as an arid region with irregular poor water resources that are geographically wrongly distributed. Theoretically, it has been shown that water availability was about 1770 m^3/habitant/year in 1955, 680 m^3/habitant/year in 1995, 500 m^3/habitant/year in 2000, and averagely 430 m^3/habitant/year in 2013 (CNES, 2000; Kherbache, 2014). Increase of demography will affect negatively and significantly the ratio since ONS (2011) plans reaching 51 million habitants by 2030 leading dropping water resources availability until esteemed alarming level of 320 m^3/habitant/year (Kherbache, 2014). Food production already failing, will be highly dreaded because food self-sufficiency needs a minimum of 912 m^3 by habitant by year (Falkenmark, 1997). Given data are positioning Algeria in difficult situation and not enabling access to self-sufficiency as it is known to occupy the 21st place among 179 countries in terms of low endowments in renewable resources by habitant (Benabderrahmane and Chenchouni, 2010; Lipper, 2011).

Considering potentialities, mobilization, organization, and utilization we put forward that water in Algeria is a major constraint to development, and this is in association to other fatal and undoubtedly insurmountable vulnerabilities due to the current economic performance (Plummer et al., 2012). We consider that remediation to water scarcity remains the economic adaptation of investments and funding.

Total mobilization capacities

The total water mobilization capacities are estimated at 18 billion m^3/year with 12.5 billion in the North (10 billion water m^3/year for surface water and 2.5 billion water m^3/year for groundwater), and 5.5 billion m^3/year in Saharan region which are considered exploitable reserves without risking hydrodynamic distortion. The long drought cycle had an impact on surface water potential in the North of the country with a significant downward trend from 6.5 billion m^3/year in the late 1970s to only 4 billion m^3/year in the 2000s. Water resources mobilization was about 2.7 billion m^3/year (63 water dams) in 2011 and will reach 4.3 billion m^3/year in the future by constructing 120 new dams. In addition to desalinated water production estimated at 2.3 m^3/year, the development of wastewater reuse was estimated in 2015 at 1.2 million m^3/year, which represents exploitable water volume about 11,000 m^3, and corresponds to a provision of only 282 m^3 per habitant and per year. The exploitable volume is close to the one estimated by CNES (2000), which is approximately 10 km^3 and relatively close to 8.4 km^3 as highlighted by Arrus (1985).

Waste water treatment

Produced drinking water in 2010 was estimated at 2,955 km^3. If we consider a loss rate of 40% between production sources and distribution by a return rate of 85% in sewer system, we can conclude that there is a significant wastewater potential which may satisfy water needs in agriculture and industry. Water quantity susceptible to be reused is estimated at approximately 1,000 m^3. Wastewater represents considerable volume of about 1.8 km^3 (Programme National Exceptionnel, 2011).

In effect, national strategy in terms of treated wastewater exploitation for irrigation purposes consists in contributing to extension of irrigated lands, increase of agricultural production, and preservation of surface and underground water resources. Reuse of treated wastewater constitutes a priority axes in water sector strategy. The objective would be to irrigate more than 100,000 ha lands by treated wastewater over 2030 horizon. It should be noted that PNE (2011) estimates reuse of treated wastewater in 2030 at 600 hm^3 as a weak hypothesis and 1.2 km^3 as strong hypothesis. Wastewater represents one of the components of the global water supply same as surface and groundwater. In Algeria, annual wastewater volume is estimated at 600 million m^3, where 550 million m^3 come from agglomerations with more than 50,000 inhabitants (Ministère des Ressources en Eau, 2003).

According to Medkour (2003) and Hartani (2004), the total treatment capacity of wastewater is evaluated at around 4 million m^3 equivalent-inhabitants for a population of 2.5 million inhabitants connected to sanitation network.

This means that only 20% of the population connected to sanitation network benefits from the treatment of those wastewaters. It was noted that 60% of wastewaters are rejected far from irrigation perimeters and dams or rejected in sea which makes reuse not profitable (Table 2). Only 240 million m^3 of water is potentially used in irrigation due to adequate location of the discharge points. The national sanitation network totals a linear length of 27,000 km. The recovery rate is about 85% if scattered population is excluded. The total wastewater volume rejected annually is estimated at 600 million m^3 with 550 million m^3 from north urban agglomeration only.

Currently, Algeria has 134 treatment plants (WWTP and lagoons) in operation with an installed capacity estimated at 12 million m^3 equivalent-inhabitant (EQH) or 800 hm^3/year. The reuse of treated wastewater, especially for agricultural purposes, has become one of the main strategic axes of the water resources sector in Algeria. Recognizing the urgency in construction and renovation of sewerage networks and wastewater treatment infrastructure, a council of ministers was consecrated in 2004 exclusively to discuss sanitation which has been seriously considered. It was decided to launch 158 new wastewater treatment infrastructures projects in different integrated programs for a total amount exceeding 2.8 billion USD. Since then, 134 treatment plants has been built with an installed capacity of about 12 million EQH or 800 hm^3/year compared to a volume of discharged water estimated at 1.4 billion m^3/year. A consequent part of the purified volume is reused for irrigation. By 2025, 56 other stations will be received, which will bring the number of treatment plants to more than 200, including 12 intended to coastal protection (Algérie Presse Service, 2020). As an example, we can cite the El-Karma station in the region of Oran (administratively named *Wilaya*) planted on an area of 8,100 ha, whose treated waters are used in agricultural irrigation of the *Melata* plain located in the south of Oran region (Hannachi et al., 2014).

The volume of wastewater discharged currently is estimated at more than 750 billion m^3 and will exceed 1.8 billion m^3 by 2030 (Algérie Presse service, 2020). In order to deal with purification wastewater potential, the water resources sector started an ambitious construction program of wastewater plants treatment. Exploited wastewater plants are actually 167 including 50 WWTP and 50 lagoons with capacity of about 570 hm^3/year. In 1999, 128 WWTP were identified with treatment capacity of 98 million m^3/day. The program underway includes 176 treatment plants (87 WWTP and 89 lagoons). The installed capacity is about 355 hm^3/year. The total installed capacity after the completion of this program will be 925 million m^3/year, which is equivalent to 10 medium dams (Kessira, 2013). The treatment and quality of water in Algeria is closely related to socio-economic and sustainable development. Reliable identification of water treatment problems and reuse can better protect this resource and integrate it effectively into the food safety agricultural production process (Negm et al., 2020a, b).

Seawater desalination

Algeria, which has 1,200 km of coastline, adopted seawater desalination (three quarters) or brackish water (one quarter) as alternative to supply drinking water to cities and localities in the coastline, and up to 60 km further from the coast (Bessenasse et al., 2010; Drouiche et al., 2011). In 2013, Algeria had nine large desalination plants in operation capable of producing up to 1.4 million m3 of desalinated water per day. The commissioning of other stations will bring the total production capacity to more than 2.5 million m^3/day. In addition to these large stations, there are around twenty small mono-block stations (with capacity range from 2,500 to 7,000 m^3/day); some of these have been relocated to reinforce water deficiency in other localities. The most important constraints of water desalination are; on the one hand, the energy consumption per cubic meters of water and on the other hand the effects on the environment due to discharge of brine, significant greenhouse gas emissions and, chemicals in the natural environment (Hamiche et al., 2018). The above data are collected from Algerian Energy Department (Ministère Algérien de l'Energie, 2020).

DIAGNOSIS OF AGRICULTURAL SECTOR

Various constraints, both internal and external, thus compete with delaying the country's food self-sufficiency, including the State's disinvestment from the agricultural sector, the orientation towards cash crops to the detriment of food crops, with the consequent amplification of the rural exodus; growing urbanization accompanied by the adoption of new eating habits oriented for the better-off towards imported products to the detriment of local food chains. Algeria is considered among the largest countries on the planet with useful agricultural area (UAA) of only 8,600,000 ha or 3.5% from the total area. All extension programs of useful agricultural area failed because of disruptive factors such as; anarchic urbanization which has already transformed more than 350,000 ha of agricultural land into urban or industrial subdivisions, an erosion affecting more than 2 million hectares, salinization induced by bad irrigation, and cultivation techniques unsuited to environmental conditions (Laoubi and Yamao, 2012; Benabdeli and Benguerai, 2014).

Useful agricultural area (UAA) compared habitants and lands occupation (ratio)

The UAA is weakly expandable because of the anthropic, natural, and demographic constraints which induced

Table 1. Evolution of irrigated areas and used systems from 2000 to 2008.

	Irrigation system (ha)			
	Total irrigated area (ha)	Gravity	Aspersion	Drip irrigation
2000	350 000	275 000	70 000	5 000
2001	617 427	458 421	102 978	56 028
2002	644 427	433 561	127 570	83 877
2003	722 320	485 019	138 301	99 000
2004	793 334	416 108	159 739	117 487
2005	825 206	524 503	153 006	147 697
2006	835 590	481 046	175 056	179 488
2007	907 293	557 327	183 182	166 784
2008	928 955	583 002	185 080	160 873

Source: Benblidia (2011).

decrease of UAA/inhabitant ratio (ha/inhabitant) from 0.74 in 1962 to 0.23 in 2012, and will likely reach 0.17 in 2030. Only 2 million hectares are receiving rainfall greater than 450 mm per year and 1.5 million hectares receive precipitations less than 350 mm per year which is enough to classify the country as agriculturally arid. On a total agricultural area (T.A.A) estimated at more than 40 million hectares, only 8.6 million are partially exploited. The Useful agricultural area (U.A.A) is badly used because absence of risk analysis since field crops represents 50% of the U.A.A, fallow represents 38%, arboriculture represents 8%, and market gardening and industrial crops represent 4%.

Irrigated surfaces status

Historical analysis of the irrigated areas in Algeria shows that irrigable area was about 330,000 ha in 1900, and since 1990s it has been estimated at 500,000 ha, but currently it stands at around 800,000 ha (Errahj et al., 2009; Bouaroudj et al., 2019). According to Benabdeli and Mohammedi (1999), the equipped and irrigated areas in Algeria are stagnating at 300,000, and more than 600,000 ha use traditional irrigation consuming an average of 3,500 m^3 water per hectare. A rational irrigation allows decreasing water use of 50% with the same obtained yields. The average water consumption per hectare for annual crops ranges from 2,200 to 7,300 m^3, and for arboriculture it fluctuates from 3300 to 5400 m^3 per hectare with an average consumption rate of about 4500 m^3 per hectare. The traditional irrigation techniques require 4 billion cubic meters, which is difficult to mobilize and distribute. Only 500,000 to 600,000 ha (Bessaoud et al., 2019) are currently irrigated among the 8.6 million hectares of useful agricultural area which represents barely 6%. This percentage is very paltry to meet basic food needs such as cereals, pulses, dried fruits and fodder (Laoubi and Yamao, 2009; Statistiques Agricoles MADR, 2018). Table 1 shows evolution of irrigated areas and used systems from 2000 to 2008 (Table 1).

Water needs compared to agricultural production.

Agricultural production, all speculations combined, covers only 60% of needs; the deficit is recorded in strategic speculations such as cereals, legumes, pulses, oilseeds and forages inducing strong food dependence (Table 2).

WATER AND FOOD SECURITY

Water controls food security and good nutrition in a variety of ways. It is the lifeblood of ecosystems, including forests, lakes, and wetlands which represents basis of food security and nutrition to the present and future generations. Water is necessary for all activities and processes related to the food system (Ericksen et al., 2010). According to Codex Alimentarius (CODEX Committee on Food Hygiene, 2000), drinking water is considered as food. For food self-sufficiency, about 2.5 m^3 per inhabitant per day is needed; representing 912 m^3 per inhabitant by year (Falkenmark, 1997), which is not the case with Algeria since the average endowment is only 400 m^3 per inhabitant per day. Looking to this chronic deficit, Algeria imports more than 17.31 billion m^3 per year as virtual water through food products which would also exceed potentials and exploitable volumes (Hoekstra *et al.*, 2012). Algeria displays in particular a desire to better exploit its agricultural potential to reduce dependence and food bill of the country while adapting to hydro climatic constraints.

Chronic water deficit managing

Water deficit is real and worrisome. Despite the mobilization and exploitation of resources, it remains

Table 2. Agricultural production and real needs.

Speculation	Production (ton)	Needs (ton)	Rate (%)
Cereals and pulses	41 000 00	90 000 00	- 55
Fruits	53 000 00	70 000 00	+ 25
Vegetable crops	130 000 00	120 000 00	+ 10
Industrial crops	14 000 00	25 000 00	- 56
Milk	1 500 000 00	5 000 000 00	- 300

Source: Benabdeli and Benguerai (2014).

present and poorly considered despite a new form of agricultural, forest, and steppe lands exploitation. This fact aggravates and accentuates the pressure on this very limited resource and essential factor for food self-sufficiency (Scherr, 2000; Zdruli, 2014). The withdrawal rates and exploitation index show a gradual transition to critical levels; it shows in 2012 a water withdrawal of 9,126.7 hm^3 over an exploitable volume of 10.47 km^3, which represents an exploitation index of approximately 87.17%. All these data puts Algeria in an uncomfortable position and ranked 21st among 179 countries in terms of low endowments in renewable resources per habitant (Lipper, 2011).

Importance of development policies

From all given data, it should be noted that Algeria is in a situation of water scarcity where the scale of the challenge can be met only if the water mobilization reaches 18 km^3 in order to ensure food self-sufficiency. Major studies on climate risks on agriculture in the region highlight shortfalls in yields of rainfed crops up to 50% during 2000-2030 periods. The rainfall deficit calculated between 1974 and 2010 (Agence Nationale des Ressources Hydriques, 2010) is around 33% in the west, 20% in the center, and 17% in the east of the country, which is considered as another factor limiting the increase of irrigated area.

The yield of strategic crops remains depending on irrigation and limited, since only 800,000 ha are currently cultivated with average yields lower than those of countries with the same soil, climate condition, and water resources. Since 2000, Algeria, has been trying to catch-up by intensifying investment in water sector and considering a long-term strategy between 1999 and 2019. Significant public funding has been allocated to the water sector to carry out the structural reforms launched in 2001-2002. The government and policymakers have adopted several urgent approaches concerning national water policy, development, planning, preservation and treatment (Negm et al., 2020a, b). Public investment in the water sector rose from 34.8 million Euros (28.5 billion Algerian dinars) in 1999 to 738.4 million Euros (594 billion DA) in 2006. The adopted strategy is based on improving water supply resources by rational use consisting in construction of dams, construction of desalination stations and, wastewater treatment plants. Algeria has undertaken big water resources projects to guarantee sustainable development and reduce dependence on food security but it was without success. The development of strategic agricultural production for an arid country like Algeria necessarily requires an optimal and rational use of water resources. The availability of water reserved for irrigation remains whatever the mobilization programs badly exploited and cannot include increasing irrigated areas. The uses of water-saving techniques remain beneficial, since they make doubling of irrigated lands surface easily possible. The methods of supplying water by moistening through a porous pipe buried in the soil at different depths depending on the type of crop constitute an interesting solution.

The contribution of water to food security and nutrition constitutes a crucial point of interaction between policies of different economic concerned sectors and even within the same sector. Despite the 16.6 billion USD (1200 billion dinars) spent in 20 years, the real impact is only 830 USD (60,000 Algerian Dinars) per agricultural plot; the constraints hampering self-sufficiency or food security still remains at the level of the risky policies adopted which have-not taken into account the basic factors of population growth, climate change, modern irrigation techniques, agro-ecology, and agro-forestry (Benabdeli and Charif, 2018).

Water metering

Regarding the chronic water deficit that Algeria is experiencing in terms of mobilizing water resources, no sustainable management measures are really undertaken by responsible authorities. In this aspect, it is important to highlight the lack of exploited water metering by farmers and industrialists through boreholes and wells with considerable fraudulence. Many specialists count more than 2,500 boreholes and 6,200 wells, where exploited volumes are often poorly assessed; those volumes are estimated at more than 1.2 billion cubic meters annually.

WATER AND EDAPHIC MANAGEMENT FOR FOOD SECURITY: NEW PROPOSED STRATEGIES

The specific rainfall Mediterranean regime covers Algeria (Navarra and Tubiana, 2013) and makes water supply essential for intensification and diversification of agricultural production to meet national needs and even exportation. The recorded water deficit does not allow increasing irrigated areas surface to more than 1 million hectares while the needs to ensure food security would be more than 2 million hectares. Currently, 55% of water resources mobilized are intended towards agriculture, 34% to food and 11% to industry. Forecast needs for 2025 are estimated at 3 billion cubic meters which is not evident to mobilize (Ministère des Ressources en Eau, 2003). More than 80% of the agricultural area is used for a cereal-fallow rotation and does not allow profitable farms regarding obtained yields (national yield average range from 10 to 13 quintals per hectare). Fallows continue to occupy more than 40% of the useful agricultural area, stressing a loss estimated at 50 million quintals of green biomass and more than 10,000 permanent jobs. We note also remarkable absence of reliable and modern agricultural holdings because of reduced surface area and technical supervision. More than 900,000 agricultural holdings have a surface area less than 10 ha which represents a total surface about 950,000 ha or 70% with a 3% technical supervision rate. Cited facts hinder any modernization allowing agricultural yields increase. Agricultural holdings stay at traditional farming methods causing underproduction resulting from bad exploitation of soil and water potentialities.

The problem that arises for Algeria is that more than 50% of its products are imported from abroad, implying that what the population consumes on a daily basis in the form of finished products or raw agricultural products is intended for processing and then consumption while the prices of food products on the national market are unstable and experience continuous fluctuations due to market conditions, which permanently poses a problem of continuity of food availability at affordable prices for small businesses, consequently a step towards food insufficiency.

New strategy

The water-agriculture sector immediately needs a new orientation in order to advance towards new challenges and paradigms with the aim of developing innovations in terms of tools and diversification, a desire to specialize sectors, economic and agricultural intensification and their necessary diversification in order to prevent risks with a view to achieving strategic food security frameworks.

A new strategy is needed and based essentially on promotion and development of private investment as a driving force of the agricultural sector within the framework of public-private partnership, private sector partners for a strengthened development of strategic agricultural sectors such as cereals, milk, fodder, seeds and meats. Also, on irrigation by water-saving systems, the modernization of farms, perhaps involves even a review of their status and mode of operation by aiming more at the integration of industrial agriculture into the productive economic fabric. The proposed strategy is based on urgent actions to ensure maintenance of the availability, quality and stability of water as contributing elements to food security through the conservation and sustainable management of landscapes and ecosystems. Adopting of ecosystem approach related to the Convention on Biological Diversity is mandatory to advance the proposed strategy. The present proposed strategy is based on urgent actions which allow significant increase of agricultural production and decrease water needs with the same mobilizations water and edaphic resources.

Rehabilitation of mountains

Mountains are gathered lands with slope higher than 12%. They represent 43% of the Northern region commonly called "*Tell*" and cover 7.5 million hectares. Mountains occupy 830 000 ha (11 %), and hosts 25% of the population (8 million habitants) which represents less than 1 ha per person. Mountain areas are completely abandoned despite all development possibilities that they contain, in particular the possibility to introduce agro-forestry. The development of mountains permits rehabilitation of around 1.5 million hectares of rustic arboriculture allowing production of 800,000 tons of dried fruit. Mountain and forest rehabilitation has given very good results allowing increase of agricultural production in several countries and can be considered as model to follow (Rerkasem et al., 2002; Zaho, 2010; Rasul and Hussain, 2015).

Scaling up the use of porous tubes for arboriculture

Arboriculture is undergoing a major structural crisis. It can indeed constitute resources that can be mobilized by local actors to develop forms of territorial enhancement (Praly, 2010). Many projects carried out between 1995 and 2000 (Benabdeli and Mohammedi, 1999) showed that use of porous tube technique requires less than 60% of water for a yield 1.5 times greater than before. The ratio per kilogram of produced biomass is only 5 m^3 for micro-irrigation instead of 9, and 13 m^3 for sprinkling. The porous tubes technique allows doubling the arboriculture area with the same water volume (Postel et al., 2009; Nouri et al., 2019).

Rational land use

The first action to be taken is to ban fallow which occupies more than 3 million hectares annually. Due to the water and rainfall deficit induced by the weak mobilization, the practice of adapting crops to drought such as barley, durum wheat, and rye is essential. Generalization of rustic arboriculture such as almond, pecan, pistachio and fodder crops is also recommended in order to develop dairy pools. Rational land exploration and arboriculture emphasis are a promising strategy in increasing agricultural production (Branca et al., 2013; Molen, 2016).

Grouping agricultural holdings smaller than 20 ha into cooperatives

Cooperatives provide a strong, viable business model suited to the needs of rural communities in developing countries. smallholder farmers derive great benefits from agricultural cooperatives, including the power to negotiate and share resources to achieve food security and poverty reduction (Cishe and Shisanya, 2019; Żmija et al., 2020). This action will affect 900,000 agricultural holdings with a total area of 2 million hectares and allows better technical management, rational and strategic exploitation of lands. This action will permit yields increasing by at least 25% (10 million quintals) with the same potentialities.

Review of water resources use and mobilization management

On the basis of all water resources, the Integrated Water Resources Management Strategy aims to direct the use and management of water resources towards efficient and appropriate distribution as well as to set the orientation of the principles management for sustainable use (Al-Saidi, 2017; Pereira, 2017; Al-Jawad et al., 2019).

This action is based on three important key points. The first principal point is represented by review of the regulatory framework, integrated management, agricultural water efficiency, and pricing policy. The second point which has priority is represented by drinking water supply, and water transfers for a new national water policy. The third point consists on the review of the legal and institutional frameworks to provide a synthetic vision of the water sector and allow appreciating changes to better respond to noted dysfunctions.

Review of investments distribution

The diversification and redistribution of investments in the agricultural sector will result in a significant increase in agricultural products transformed into differentiated products with high added value. Investment in the agricultural sector also improves agricultural productivity and relates to the development of agriculture business and agro-industries (Hallam, 2009; Usman et al., 2017; Sakhno et al., 2019). In case of Algeria, a quota of 35% is recommended for water resources mobilization, 20% for extension of orchards and vineyards, 10% for the development and renovation of productive potential, 15% for intensification of strategic crops, 10% for agricultural land development and lastly 10% for training, research and vulgarization actions (Bouis, 2000). Additionally, the primordial element which is at the base of the development of agriculture is Man. Thus, development can only be achieved through the strengthening and consolidation of human potential. Therefore, investments in various fields, health and education are the best guarantees of increasing the real potential of the rural population.

Better water governance

The worsened situation of the bad water governance is due to certain inadequate practices resulting from lack of coordination and the almost absolute marginalization of the role of the citizens. Good water governance can be applied by coordination between sectoral policies (environment, energy, trade, food and agriculture, including fisheries, forestry, and industry) to avoid repercussions on water resources (Woodhouse and Muller, 2017; de Amorim et al., 2018). We propose to set up high-level institutional mechanisms to ensure horizontal coordination of water policies mainly involving the relevant ministries, and also inter-ministerial bodies, commissions and committees to serve as platforms of dialogue and action between public actors at central level. National actions must be accompanied by partnerships and exchanges of experience and expertise at the international level, as cooperation strengthens the capacity of actors and institutions.

Intensification of cereal production

Cereal production is a key component helping to ensure food security instead of food self-satisfaction (InterAcademy Council, 2004). The world population should reach 9.1 billion habitants by 2050 which represents a daily increase of 200,000 inhabitants. The demographic growth will take place mainly in Asian and African countries where problems linked to undernourishment are strongly present. World agricultural production is expected to double by 2050 and the expected productivity gains allow grain to be sold quickly with a reasonable price. Also, cereals will eventually become a strategic force and consequently political power. The intensification of cereal production is a challenge for several countries, but the ecological choice must be the most preferred, as agriculture will be sustainable, resilient and adapted to the environments (Cassman et al., 2003; Massawe et al., 2016). In case of intensifying agricultural production, it is important to consider the role of fertilizers and their impact on the environment. Food security is strongly linked to a rational management of fertilizers and seeds in order to avoid the misuse of herbicides and to guarantee a healthy production of food for the animals (Yigit et al., 2016; Kaya et al., 2019; Yucedag et al., 2019). It is also essential to note that development of the fodder potential, by reducing fallow land and mobilizing irrigation water for fodder, makes it possible to develop the dairy field, which is an essential sector of food security.

CONCLUSION

The modernization of exploitation methods for water resources and agricultural cultivation techniques are an unavoidable necessity permitting increase in agricultural yields. It will also help to control, in priority, strategic speculations in cereals, pulses and fodder. Food dependence in Algeria requires a revolution in terms of land use planning to identify, eliminate and assess the potential of each territory. This phase is essential to adopt a strategy for sustainable exploitation of lands through their resources which are soil, water, landscape and human potential. It is also important to note that energy is a crucial factor in close relation with water and food security, hence the need to adopt a water-energy-food approach (WEF) allowing reduction dependence to fossil fuel and diversification of water resources and energy supply. The adoption of WEF nexus concept offers many environmental and economic benefits to Algeria (Khacheba et al., 2018).

The most important solution to reducing food dependence and importation is effective mobilization of skills with several experiences in agricultural field in order to first stop degradation of natural resources and use of State funds to doomed programs. We suggest that it is important to prioritize all the processes for preservation and local development of natural resources (in particular soil and water resources), as well as actions to rehabilitate infrastructure use as part of sustainable rural policy development. The lands management consists of reasoning and acting at the level of a well-defined space corresponding to a geo-ecological entity with the same potentialities and characteristics. This approach will permit highlighting relationships between the various factors acting on improvement of agricultural production.

Looking for achievement of food self-sufficiency or at least food security necessarily involves a new policy essentially focused on reorganization of territories. Mobilization of human skills and investments related to training, research and extension in the agricultural field will be beneficial.

It is highly recommended that producers of cereals and pulses must perform and improve strategy to meet an increasing demand, because cereals are the staple foods in our diet and are increasingly recognized as a health factor. Particular importance should be given to starchy foods which are the main source of energy for our body and main supplement to the Algerian people diet based on cereal; this is in view of the low purchasing power and the high cost of fruits and vegetables.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENTS

The authors thank the Editor for his valuable comments and suggestions which improved the content and presentation of this paper. Professor Duncan Hilchey, Co-director of Lyson Center for Civic Agriculture and Food Systems (USA) and Professor Barbara Sawicka - Head of Department of Plant Production Technology and Commodity Sciences from University of Life Sciences in Lublin (Poland) are also appreciated for their relevant remarks, suggestions and valuable advices.

ABBREVIATIONS

ANRH, National Agency for Water Resources; **APS,** Algerian press service; **CFS,** Council Food Security; **CNES,** Economic and social national council; **EQH,** equivalent-inhabitant; **FAO,** Food and Agriculture Organization; **MAE,** Algerian Ministry of Energy; **MRE,** Ministry of Water Resources; **OECD,** Organization for Economic Co-operation and Development; **ONS,** National Statistics Office; **PNE,** National water policy; **TAA,** total agricultural area; **UAA,** useful agricultural area; **WEF,** water-energy food approach; **WWAP,** World Water Assessment Program; **WWTP,** Wastewater treatment plant.

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