



Dynamics of Potato Cultivation in the Arid Saharan Region of El Oued (Algeria) and Farmers' Perceptions and Adaptations to Climate Change

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Abstract: The arid areas of Algeria, which cover more than 80% of the national territory, are particularly vulnerable to the effects of climate change. In this context, this study analyses the dynamics of potato cultivation in the Saharan region of El-Oued and farmers' perceptions and adaptation strategies to climate change. The methodological approach combines analysis of statistical data from the Directorate of Agricultural Services (DSA)(1999-2024) and a field survey of 27 producers. The results show spectacular expansion of cultivation, with areas increasing from 628 ha in 1999 to over 40,000 ha in 2022, supported by the mobilization of fossil aquifers and the widespread use of pivot irrigation. However, this growth relies on non-renewable water resources, raising significant sustainability issues. Local perceptions reveal that over 80% of farmers have noticed rising temperatures, but the majority do not perceive other manifestations of climate change, due to dependence on irrigation and the perception of sufficient water availability. The most frequently cited adaptation strategies involve modifying the cropping calendar, improving irrigation systems, and diversifying crops, particularly towards market gardening under Multispan greenhouses, which could make El-Oued a future hub for market gardening in addition to potato production. The study highlights the need to strengthen technical training, varietal innovation, and sustainable water management to ensure the long-term resilience of this strategic sector.

Key words: Climate change, arid areas, potato, farmers' perceptions, adaptation, Algeria.

Arid areas, which cover around 40% of the Earth's surface and are home to nearly 40% of the world's population, are among the most vulnerable to climate change (Carpio, 2021; INRAE, 2020). The Maghreb countries, located south of the Mediterranean, are particularly sensitive to these changes. They face several threats: increasingly intensive agriculture, water scarcity, desertification, natural disasters, drought, silting, and forest fires (Sahli and Amrani, 2019; Jourdan *et al.*, 2022; Taïbi, 2023).

In Algeria, considered one of the countries most vulnerable to climate change (Taïbi, 2023), public authorities have committed to a proactive policy to combat and adapt to climate change. The country has adopted a favorable legal and strategic framework, embodied in the National Climate Plan (NCP), which brings together all planned actions to mitigate greenhouse gas emissions and adapt to the effects of climate change (Jourdan *et al.*, 2022; Ghezloun, 2021; GIZ, 2019). Within this framework, a National Climate Committee (CNC) has been set up under the supervision of the Ministry of the Environment to strengthen the coordination, monitoring, and evaluation of national climate policies, in line with Algeria's commitments under the United Nations Framework Convention on Climate Change (Crumpler *et al.*, 2022).

Most of Algeria's territory (nearly 87%, or approximately 2 m km²) consists of arid Saharan areas, characterized by significant but non-renewable water resources (Bouselsal *et al.*, 2014; FAO, 2020; MEER, 2023; Mokhnane *et al.*, 2025). Over the last few decades, these regions have undergone significant socio-economic changes, supported by a strong political will to promote their development, particularly through the growth of Saharan agriculture (Amrouni Sais, 2024; Sahali and Sahnoune, 2019). This strategy aims to strengthen national food security and improve the living conditions of populations living in these fragile areas (DGRSDT, 2020).

Thanks to investment programs and government support, some areas, such as

Zibans and Souf, have become major centers of vegetable production (Ould Rebai *et al.*, 2023). In this context, the arid area of El-Oued has seen a remarkable boom in potato cultivation, which is now the wilaya's main agricultural crop. El-Oued is now the leading potato-producing area in Algeria, supplying around 40% of the national market (Ouendeno, 2019; Amrouni Sais, 2024). El-Oued is a relatively new region for potato cultivation, with the first trials of the crop launched in 1995. Since then, the area under cultivation has continued to increase (600 ha in 1995 compared to 36,209 ha in 2021) (Amrouni Sais, 2024).

However, despite this outstanding dynamics, a key question arises: can this expansion be sustained in the face of the growing effects of climate change? How do farmers perceive these developments, and what are their strategies for adapting to this global phenomenon? The aim of this study is to assess the impact of climate change on potato cultivation in the El-Oued area and to analyze the adaptation strategies implemented by farmers. More specifically, it seeks to describe how this crop has evolved over the years, identify the perceived effects of climate change on production, and examine the main adaptation practices adopted at the local level.

Materials and Methods

The wilaya of El-Oued (Fig. 1), located in southeastern Algeria, is one of the main oases in the northern Sahara. It covers 35,752 km² and comprises 22 municipalities. It is bordered to the north by Khenchela and Biskra, to the



Fig. 1. Location of the study area (Source: <https://gifex.com>).

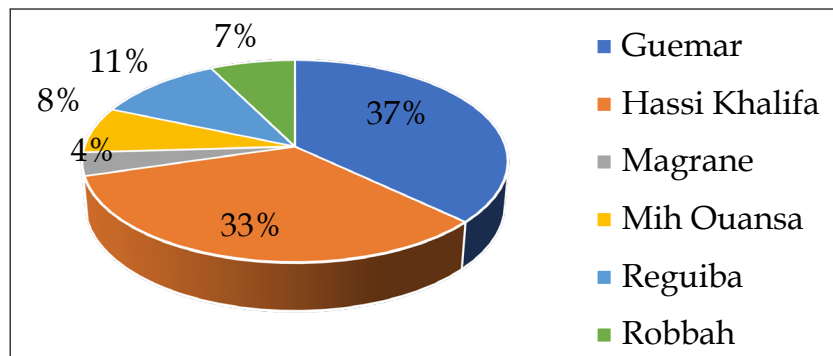


Fig. 2. Location of farmers surveyed.

west by El M'Ghair and Touggourt, to the south by Ouargla, and to the east by Tunisia (Ould Rebai *et al.*, 2017; Bakini and Teksebti, 2021). The region under study, commonly known as Souf, is located between latitudes 32°30'00" and 34°12'00"N, and longitudes 6°15'00" and 7°20'00"E. It is characterised by a landscape of ergs and dunes that can reach heights of up to 100 m (Mokhnane *et al.*, 2025). The climate is arid, typical of the Sahara, characterized by extreme temperature variations: temperatures range from 4°C in January to 42°C in July, with an annual average of 23°C (Bakini and Teksebti, 2021). Rainfall is low and irregular, with an average annual rainfall of less than 60 mm (Remini and Souaci, 2019). Winds, particularly the sirocco and sandstorms, are a determining factor for local agriculture, causing drought and wind erosion with speeds reaching 60 km hr⁻¹ (Bakini and Teksebti, 2021).

Regarding water resources, the El-Oued area contains an aquifer system comprising three aquifers: the shallow unconfined aquifer, the terminal complex aquifer, and the deepest continental intercalary aquifer. These aquifers are exploited to meet the population's drinking water and irrigation needs (Bouselsal *et al.*, 2014). These aquifers contain the largest water reserves in southern Algeria. However, harsh climatic conditions, characterized by low rainfall, high temperatures, and high evaporation, indicate a negative water balance, with minimal groundwater recharge in southern Algeria (Mokhnane *et al.*, 2025).

The evolution of potato cultivation in the wilaya of El-Oued was studied using statistical data from the Directorate of Agricultural Services (DSA) covering the period 1999-2024. This data mainly concerns: cultivated areas,

average yields (t ha⁻¹), total production (t), and the spatial distribution of production areas.

Analysis of this data enables monitoring the sector's development dynamics in the area and assessing trends amid climatic and water constraints.

In addition to statistical data, a field survey was conducted to gather farmers' perceptions of the impact of climate change. The questionnaire was administered between September and October 2025 to a sample of 27 potato producers who had been growing potatoes for more than five years, spread across several producing regions (Fig. 2).

The questionnaire consists of three main sections: i) socio-economic characteristics of farmers and farming practices (location, farm size, farming experience, irrigation sources and methods, variety choices, crop calendar), ii) perceptions of climate change and its impact on production (perceived changes in temperatures, rainfall, winds, water availability, emergence of diseases and pests, yield losses), iii) adaptation strategies and measures adopted or planned in the medium term.

The data from the questionnaire were entered and processed using Microsoft Excel 2019, enabling descriptive statistics and graphical representations to be produced. This analysis highlighted the main climate risks perceived by farmers and the adaptation measures implemented.

Results and Discussion

Evolution of potato cultivation and production

An analysis of potato cultivation trends in the province of El-Oued between 1999 and 2024 (Fig. 3) reveals spectacular growth in both area

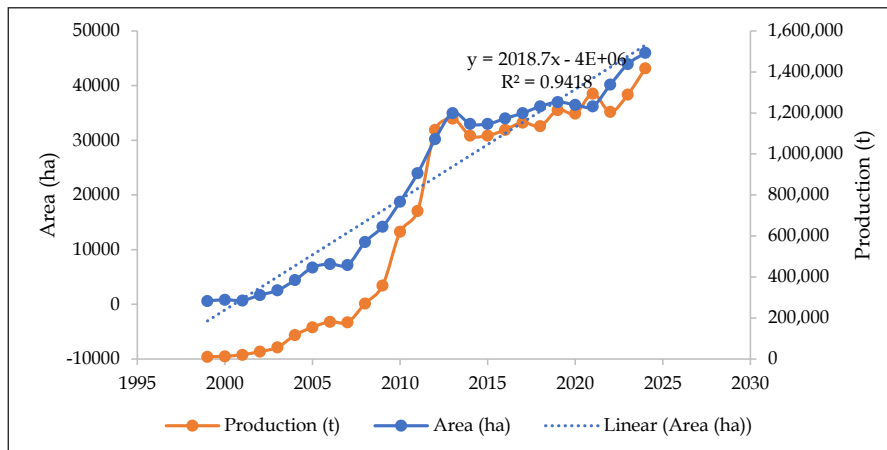


Fig. 3. Evolution of the area and production of potatoes in El-Oued (1999-2024) (DSA, 2025).

and production. The area planted increased from 628 ha in 1999 to more than 46,000 ha in 2024, a 70-fold increase over 20 years. Statistical analysis of the trend reveals a strong linear relationship between years and area ($y = 2018.7x - 4E+06$; $R^2 = 0.9418$), indicating an average annual increase of approximately 2,018 ha. The high value of the coefficient of determination indicates a strong temporal correlation, confirming the steady, sustained growth of cultivation over time. This expansion has been accompanied by an exponential increase in production, rising from 11,122 t to over 1.4 m t during the same period. This dynamic reflects the technical and economic success of the sector in an arid Saharan context (Amrouni Sais, 2024; Ould Rebai *et al.*, 2017; Blom-Zandstra *et al.*, 2020; Ouendeno, 2019), facilitated by the mobilization of groundwater (Ariom *et al.*, 2022; Mokhnane *et al.*, 2025), the rapid spread of pivot irrigation systems, and the strong entrepreneurial motivation of local

producers (Ould Rebai *et al.*, 2017). However, this growth is based on the intensive exploitation of non-renewable water resources and raises major environmental sustainability issues (Ariom *et al.*, 2022, Blom-Zandstra *et al.*, 2020), including soil salinisation, overexploitation of groundwater and the amplifying effects of climate change, which are likely to affect the long-term viability of production (Allal *et al.*, 2023).

Characteristics of potato production

The study conducted among the farmers surveyed reveals a predominance of large farms in potato production in the study area. In fact, 85% of farms cultivate more than 10 ha, reflecting a marked shift towards large-scale production, while small farms (1 to 5 ha) account for only 15% of the sample. This trend confirms the intensification dynamic observed in Saharan areas (Houben *et al.*, 2017; Ouendeno, 2019; Mokhnane *et al.*, 2025). The

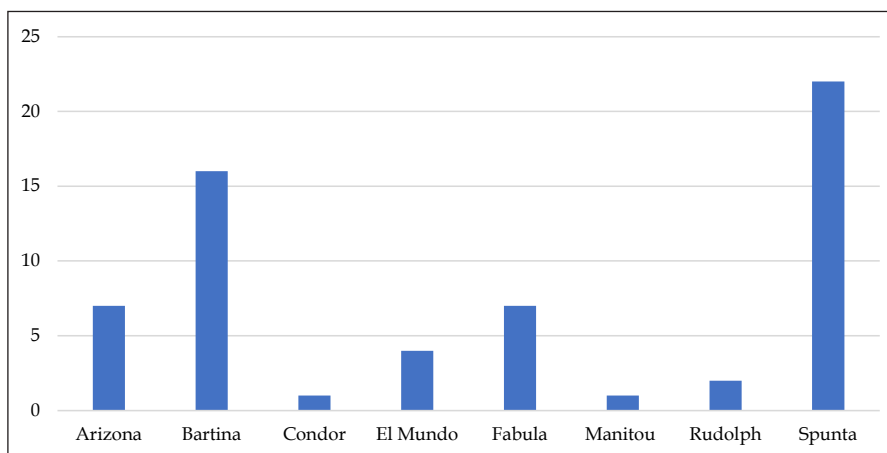


Fig. 4. Varieties used by farmers.

largest producers have a significant number of irrigation pivots, around 30 on average, with some having up to 70, knowing that one pivot covers around 0.9 hectares (Houben *et al.*, 2017). In terms of land tenure, all the farmers surveyed own their land and practice direct cultivation, a situation that promotes stability and long-term investment, reflecting a sustainable commitment to agricultural activity.

Analysis of the varieties grown reveals moderate diversity, with eight varieties identified (Fig. 4). The Spunta variety dominates the choices, accounting for 81% of farms, due to its high commercial demand, its adaptation to local conditions, and its high yield potential (PASA, 2022a; Yahi and Djaafour, 2022; PASA, 2022b). It is followed by Bartina, grown by 11% of farmers and appreciated for its tolerance to moderate salinity in irrigation water (PASA, 2022a). However, recent studies have shown that newer varieties, such as Arizona, Manitou and Rudolph, offer higher yields than Spunta, suggesting the need for gradual renewal of plant material to increase crop productivity and resilience (Blom-Zandstra and Michielsen, 2020).

Average yields indicate a good level of productivity, with an average of 32.4 t ha⁻¹, although there is some seasonal variation: around 40.0 t ha⁻¹ in the main season compared with 28.5 t ha⁻¹ in the late season. These results reflect the proven expertise of local producers (Yahi and Djaafour, 2022), especially given that cultivation remains largely unmechanized (Houben *et al.*, 2017). Irrigation systems are diverse, but dominated by centre pivot irrigation (78% of farms), in line with

the observations of Houben *et al.* (2017) and Ariom *et al.* (2022). Drip irrigation is used alone in 22% of cases, mainly on medium-sized or small farms. According to Blom-Zandstra and Michielsen (2020), the introduction of underground fertigation (subsurface drip) has resulted in water savings of more than 50% and a slight increase in yield (from 9.2 to 11.5 t ha⁻¹), demonstrating the potential of this technique to improve water sustainability in arid areas.

Perception of climate change

Local populations across different regions of the world perceive climate change through rising temperatures, reduced rainfall, disrupted rainfall patterns, prolonged periods of drought, and changes in water resource availability (Karam and Adjiziane Gérard, 2023; Taibi, 2023; Chabane, 2012; Léвите, 2016; INRAe, 2020, Benhaddad, 2022). Research on climate change unanimously highlights its direct impact on agriculture, particularly on potato cultivation, whose productivity and quality are particularly sensitive to variations in temperature and water regime. (Paterson, 2025; Faci, 2021; Benhaddad, 2022; Ouhamdouch *et al.*, 2018; Boucetta, 2018; Faci, 2018, InfoResources, 2008). Night-time temperatures above 22°C inhibit tuber formation, compromising yield and quality (InfoResources, 2008; Paterson, 2025).

Farmers perceive these changes through increasingly pronounced climatic signals, such as reduced and delayed early-season rainfall, increased recurrence of droughts, and prolonged heat waves (IPCC, 2022), but some of these factors are difficult to perceive in arid regions (Karam and Adjizian Gérard, 2023). For

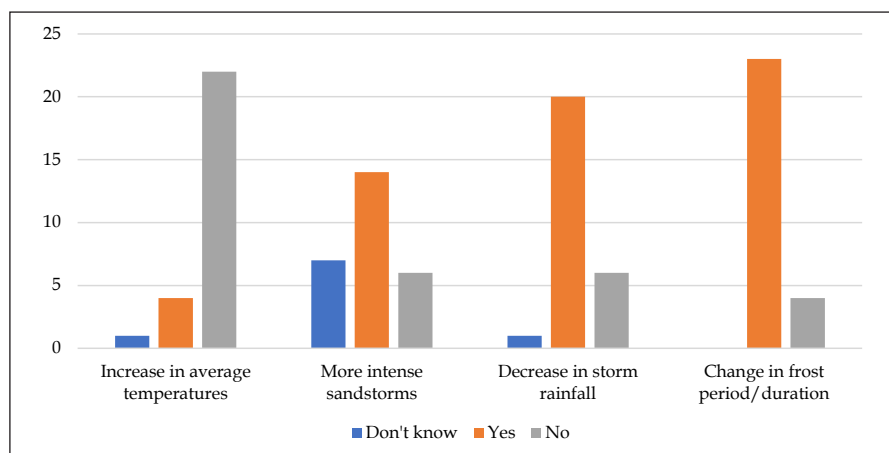


Fig. 5. Farmers' perception of climate change.

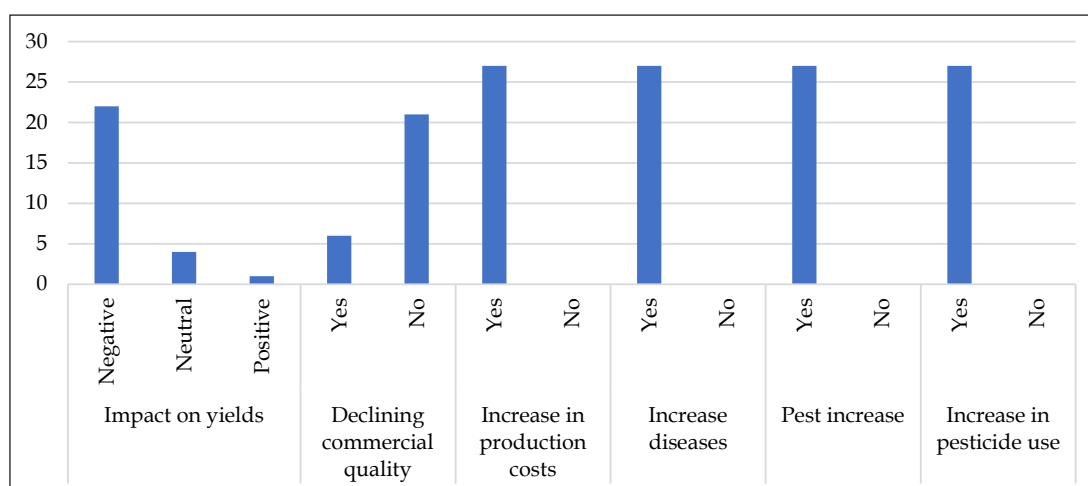


Fig. 6. Impact of climate change on production ($t\ ha^{-1}$).

example, potato farmers surveyed in the El-Oued area had different perceptions of climatic parameters (temperature, wind, precipitation, and frost). Most of our respondents (over 80%) acknowledged that temperatures have risen in recent years compared to previous years. However, changes in storm rainfall, periods of frost and wind intensity were not noticed by a large proportion of our respondents (Fig. 5).

According to the IPCC report (2022), North Africa is experiencing global warming at twice the global average rate, with an increase of 0.2 to 0.4°C per decade since the 1970s and a marked increase in heat waves. Furthermore, projections indicate a continued rise in temperatures and a gradual decline in rainfall, accompanied by increased variability in agricultural seasons. This discrepancy between the observed climate reality and farmers' perceptions reflects the potential vulnerability of the cropping system to thermal and physiological stresses that could affect potato productivity and quality in El-Oued.

Analysis of data collected from farmers in the El-Oued area shows that the high temperatures and climate irregularities observed in recent years have encouraged the proliferation of pests and the resurgence of plant diseases, increasing the vulnerability of crops (Fig. 6). This situation has led to an increase in the use of plant protection products, as reported by all the farmers surveyed (100%), a finding that is consistent with the results obtained by PASA (2022b). Indeed, the rise in temperatures caused by global warming inevitably increases

pest and health risks, as well as costs (Chabane, 2012; InfoResources, 2008).

Similarly, 100% of farmers reported a dramatic increase in production costs as a direct result of intensified treatments and climate disruption. According to farmers, the most affected item remains organic fertilizer, consisting mainly of poultry manure (PASA, 2022b). This manure comes from other regions specializing in livestock farming and is transported by lorries of various sizes. Whereas previously it was purchased at local markets, a new manure market has recently been created in response to growing demand. Prices vary according to the type of livestock farm of origin and the size of the transport vehicle (Ouendeno, 2019).

Farmers' perceptions of the effects of climate change on potato cultivation show that the majority of them (81.5%) have noticed a negative impact on yields (Fig. 6). Unlike yields, commercial quality has not been affected according to 78% of farmers, whereas numerous studies highlight the negative effects of global warming on the quality of agricultural products, particularly on the size, dry matter content and storage life of tubers (Paterson, 2025; Faci, 2021; Benhaddad, 2022; Ouhamdouch *et al.*, 2018; Boucetta, 2018; Faci, 2018; InfoResources, 2008). This discrepancy can be explained by several factors. Firstly, the perceived resilience of quality may be linked to the selection of tolerant varieties (such as Spunta or Bartina). Secondly, the priority given to yields and marketable quantity often leads producers to assess quality according to

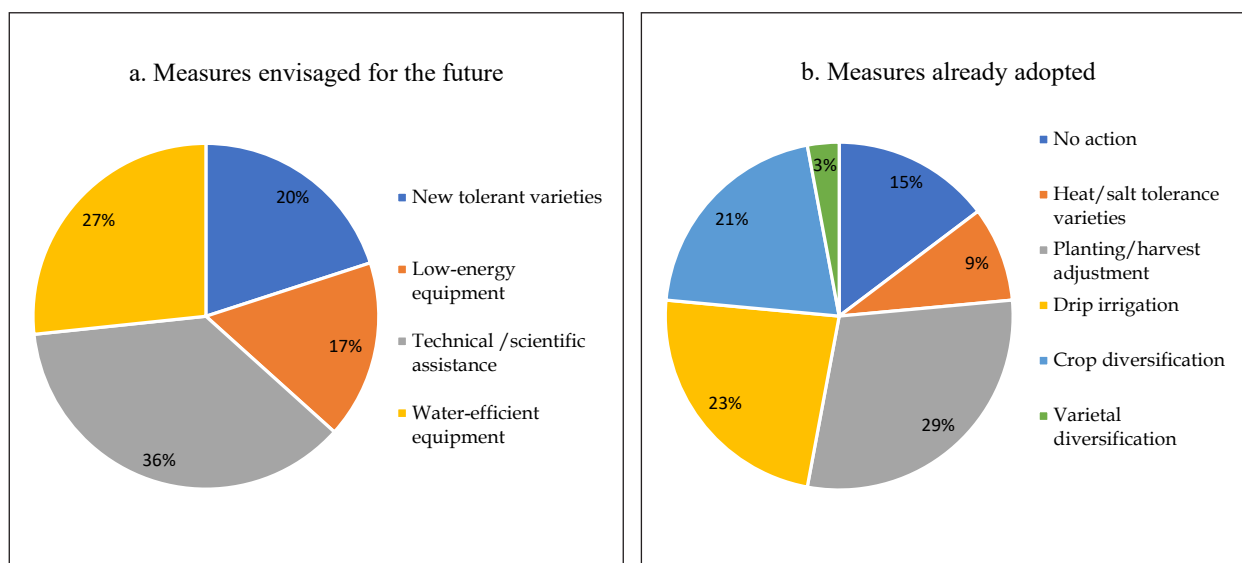


Fig. 8 (a,b). Measures adopted and planned to combat global warming

reflect a desire to optimize water resource use. On the other hand, the adoption of heat or salinity-tolerant varieties, as well as varietal diversification, remains limited, mainly due to the lack of suitable plant material (AFC, 2022) and insufficient technical advice (Allal *et al.*, 2023; Blom-Zandstra and Michielsen, 2020; Yahi and Djaafour, 2022).

In the El-Oued area, crop and income diversification appears to be a key adaptation strategy in the face of the growing effects of climate change. This finding is consistent with several studies conducted in Africa, which emphasize that agricultural diversification and flexible practices are major responses to reducing the vulnerability of rural households (IPCC, 2022; Paterson, 2025; Hilaire, 2025). Adjusting sowing dates and choosing early maturing or drought tolerant varieties help to strengthen resilience and yield stability (IPCC, 2022; Paterson, 2025). However, these strategies remain limited by economic and institutional constraints, in particular limited access to technical information, appropriate inputs and financing (IPCC, 2022).

Faced with these challenges, the survey results show that farmers in El-Oued are increasingly interested in technical training and scientific assistance, which they consider essential to strengthening their adaptive capacities. The acquisition of water and energy efficient equipment and the introduction of new, more resistant varieties are also among the priority measures being considered. These approaches

reflect a desire for gradual adaptation and openness to innovation, but they require sustained institutional and financial support. Strengthening local capacities, disseminating climate-adapted innovations, and implementing incentive policies appear to be essential to support the sustainability of potato production in this arid region (Allal *et al.*, 2023; Blom-Zandstra and Michielsen, 2020).

Analysis of the responses from the farmers surveyed shows that the main risks perceived in potato cultivation are primarily economic and phytosanitary. Marketing is cited by 39% of producers as the main risk, linked to high price instability (Paterson, 2025) and weak regulatory channels (Bessaoud and Lefki, 2018). Phytosanitary problems (23%), nematodes (10%) and seed quality (13%) reflect the technical vulnerability of the production system. Successive potato cultivation on the same pivot gradually depletes the soil and promotes the spread of nematodes, a phenomenon observed after the sixth crop cycle (three years) according to Ouendeno (2019). In addition, the El-Oued region has a growing need for seeds, which are generally produced in the north of the country or imported. However, in recent years, many farmers have complained about the poor quality and high cost of imported seeds, leading them to produce their own seeds locally (AFC, 2022).

On the other hand, risks related to rising temperatures or water shortages are mentioned by only 3% of respondents, suggesting a low perception of climate risk despite the

effects already observable in crops. This diminished perception is mainly explained by the fact that potato cultivation in El-Oued is entirely irrigated, with farmers believing that sufficient water remains available thanks to the widespread use of groundwater. This situation creates an illusion of water security, which partly masks the real impacts of climate change on the resource.

This finding contrasts with observations at the African level, where farmers are increasingly aware of climate signals such as reduced and delayed early-season rains, increased recurrence of droughts, and prolonged heat waves, which they directly associate with yield declines (IPCC, 2022). This divergence illustrates the specificity of irrigated arid areas, where access to groundwater temporarily mitigates climate effects, while postponing risks to long-term sustainability.

Agricultural decisions are often based on empirical knowledge passed down locally. Lack of access to technical training and digital tools hinders adaptability and impedes the transition to more sustainable agricultural practices amid climate uncertainty (Allal *et al.*, 2023).

Regarding to the future outlook for cultivation, most producers say they are optimistic: nearly half (13 out of 27) want to keep doing what they are doing, and eight farmers are even thinking about expanding their land. Farmers tend to increase the area under cultivation in response to economic incentives, namely prices (Benmehaia and Oulmane, 2021). A significant proportion (7 producers) plan to diversify into greenhouse vegetable growing, which is perceived as more profitable and better suited to local climatic constraints. In the medium term, this shift could make the El-Oued region a major center for vegetable production in Algeria. On the other hand, three producers say they want to abandon potato cultivation and only one plans to stop all agricultural activity, demonstrating overall resilience but also a gradual awareness of the limitations of the current model.

Conclusions

The study conducted in the Saharan area of El-Oued highlights the rapid expansion of potato cultivation, driven by pivot irrigation and the mobilization of fossil aquifers, making

this region the main production basin in Algeria. However, this development is based on an intensive model that depends on non-renewable water resources and is exposed to the effects of climate change. Farmers mainly perceive rising temperatures, while other climatic manifestations remain poorly identified due to the apparent availability of irrigation water. Faced with these constraints, several adaptation strategies are emerging, such as modifying crop calendars, improving irrigation and diversifying into, and diversifying into multispan greenhouses and market gardening. Strengthening technical training, agronomic innovation, and sustainable water management appears essential to ensure the resilience and sustainability of this strategic sector in an increasingly challenging climate context.

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