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WATER SCARCITY IMPACTS ON FOOD PRODUCTION IN MOROCCO

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Abstract: The aim of this article is to determine whether current freshwater reserves will be sufficient to meet growing agricultural needs in a context of water scarcity. This study also examines whether population growth, water supply and demand models resulting from climate change, will ensure Morocco's sustainable food production. Indeed, the depletion of freshwater reserves is a worrying problem in many parts of the world. To address this situation, new water conservation and biotechnology technologies have been developed, as well as wastewater treatment methods for recycling and reuse. Despite the progress made in terms of agricultural practices and cropping innovations under the Green Morocco Plan, Morocco's food supply continues to face the effects of climate change on water and land resources utilized in food production.

Keywords: water scarcity; food security; climate change; Green Morocco Plan; land degradation

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1. Introduction

The projected growth in population and household incomes suggests a 70 to 100% increase in food demand by 2050 (USDA, n.d.). As the population expands and incomes rise, concerns are rising regarding the ability of existing resources to meet future food requirements. These concerns encompass various aspects such as land and water resources, advancements in technology and sustainable agricultural practices, as well as the efficacy of international trade agreements. While it is desirable to address these aspects collectively, this article primarily focuses on technological advances that play a key role in the ability of food production to adapt to the challenges of water scarcity in the context of climate change.

Adopting the FAO's definition of food security as reaffirmed by Schmidhuber and Tubiello (2007), it encompasses the notion that Food security is achieved when every individual maintains uninterrupted physical, social, and economic access to sufficient, safe, and nourishing food that meets their dietary needs and preferences, enabling them to lead an active and healthy life (FAO, 2002). Food security comprises multiple elements, such as the

availability of food through production and trade, accessibility to food, stability of food supply, and efficient utilization of food resources (FAO, 2017, 2006, 2002).

Despite considerable progress over recent decades to reduce hunger, in 2016 nearly 815 million people is chronically undernourished (FAO, 2017). The United Nations Food Organization (FAO) shows that approximately 161 million children under the age of five suffer from stunted growth. Simultaneously, an alarming number of 500 million people are affected by obesity. These figures highlight the dual challenges of malnutrition, with undernutrition and over nutrition posing significant health risks globally. Two billion people lack the essential micronutrients they need for a healthy life. The FAO also reveals that, to meet rising demand linked to population growth and changing diets, food production will need to increase by 60% by 2050 (FAO, 2017).

The rising scarcity of water and its fluctuating availability pose a significant policy concern regarding the Earth's capacity to meet the increasing food demands of a larger population with limited resources per person. Addressing this concern involves potential strategies such as the development of technologies that promote faster crop growth, reduced water and fertilizer requirements, and higher yields per unit of land. Additionally, exploring options to utilize lower quality water and cultivate crops on less fertile soil could also be considered as potential solutions to mitigate the impact of water scarcity and resource limitations (Mann, 2018).

The potential of natural water resources in Morocco is estimated at nearly 22 billion cubic meters in an average year (surface water: 18 billion cubic meters per year and groundwater: 4 billion cubic meters per year). This potential is characterized by great territorial disparity: more than 70 % of surface water is concentrated on less than 15 % of the national territory in the extreme north-west of the Kingdom. Morocco currently has 140 large dams with a total capacity of 17.3 billion cubic meters (BENNOUNA, 2020).

However, water scarcity in Morocco is being affected by climate change, through rising temperatures and irregular rainfall. And we know that due to the influence of climate change it is evident that there will be a decrease in the availability of water for irrigation, energy generation, as well as domestic and industrial purposes. This also means more stress on ecosystems along rivers. The recent severe droughts are a warning of what could happen in our country, and particularly in the southern and eastern Mediterranean countries in the future. The increasing frequency and intensity of such events have the potential to jeopardize water availability and food security. With climate change exacerbating the variability of weather patterns, extreme weather events like droughts, floods, and storms can significantly impact agricultural productivity and water resources both in our country and in other southern and eastern Mediterranean countries.

Morocco's current water shortage is an urgent problem that is likely to impose major constraints on the country's economic development and food security for decades to come. The agricultural sector will be the first victim of the water shortage. This situation is exacerbated by the fact that agriculture employs around 40 % of the country's workforce; and that the agricultural sector is Morocco's leading water consumer (over 85 % of available water).

The utilization of Moroccan data on water resources, population growth, and land allocation for food production forms the basis of our analysis. In this study, we explore the dynamics of food production within the context of climate change. Our focus is on understanding the implications of water scarcity and exploring technological advancements that have the potential to ensure a sustainable food supply, even in the presence of limited water resources.

It is important to note that the discourse surrounding water scarcity and the methodologies employed for its assessment is not a recent development.

Recent literature, such as Damkjaer and Taylor (2017) and Xu and Wu (2017), discusses indices of water accessibility, clearly suggesting that there is no single indicator of water scarcity that meets all needs. The literature considers several indices of water scarcity, including: (1) the ratio of withdrawals to freshwater availability (WTA), which measures water scarcity as a percentage of available water resources. This measure, as proposed by Raskin et al. (1996), indicates that a higher ratio signifies a greater degree of water scarcity; (2) the Water Stress Index (WSI), introduced by Falkenmark (1986), represents the amount of renewable freshwater accessible per capita in a specific region, country, continent, or globally. The WSI provides insight into the level of water scarcity experienced in a given area.

The selection of the Water Stress Index (WSI) for our study was driven by multiple factors. Firstly, the WSI was originally developed to guide the formulation of strategies aimed at achieving food self-sufficiency, taking into account anticipated droughts and population growth, which closely aligns with the variables under examination in our research. Secondly, the WSI has gained prominence as the prevailing metric for assessing water scarcity within the existing body of literature, as highlighted by the work of Damkjaer and Taylor (2017). Lastly, the utilization of the WSI enables us to analyze interannual trends of water scarcity, a crucial aspect that supports the comprehensive analysis conducted in our paper.

Furthermore, indicators such as water and land ratios at the global and regional levels are utilized to assess the trends in food security risks in different locations. These ratios mentioned which evaluate water and land availability per capita, play a crucial role in capturing and understanding the fluctuations in the quantity and quality of these resources. They offer valuable insights into their influence on food production across diverse timeframes and geographical regions (McLaughlin and Kinzelbach, 2015). By concentrating on water and land availability per capita, we can effectively monitor trends over time and analyze patterns across different continents. This approach allows for a comprehensive assessment of the relationship between resource availability and food production.

Our initial focus is on providing an overview of global data pertaining to population growth, water availability, land availability, and food production. We also consider the implications of climate change, which can exacerbate water scarcity and consequently impact food production. Additionally, we explore potential approaches for enhancing local water supply through the utilization of wastewater, harvested water, and flashflood water for irrigation purposes. Furthermore, we introduce advancements in technology and agronomy and their potential effects on improving irrigation water use efficiency. These advancements encompass areas such as salinity management, drought resistance, and insect tolerance.

2. Determinants of food availability

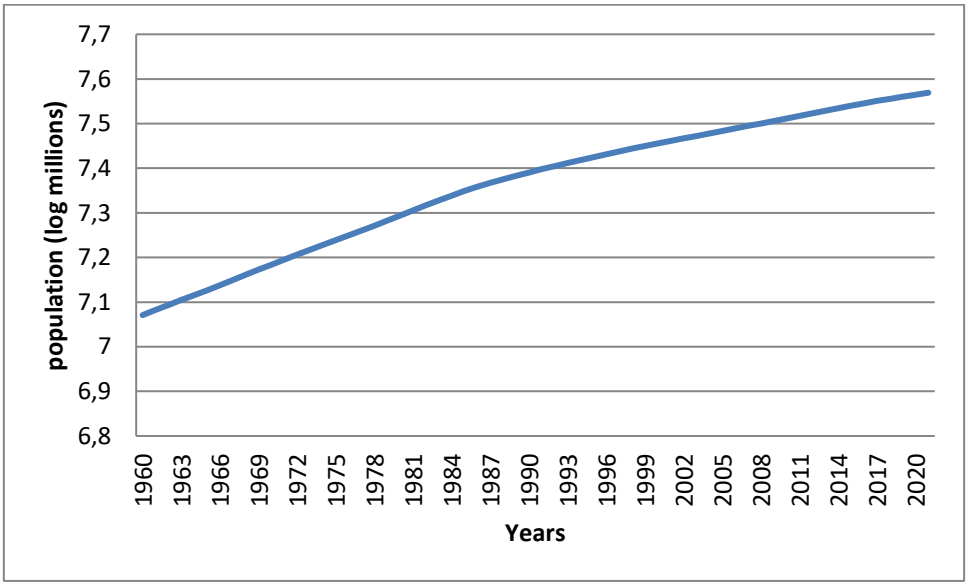
We present a simple analysis of the main resources associated with food production, namely the availability of land and water resources, but also the influence of population growth on food availability.

2.1 Population growth

In 1798, Malthus proposed the idea that population growth follows a geometric progression, while food supply increases at a slower arithmetic rate. Consequently, Malthus argued that population growth would surpass the capacity of land to provide an adequate food supply, leading to potential food shortages. Building upon Malthus' theory, neo-Malthusian authors such as Ehrlich and Wilson (1991) and Ophuls and Boyan (1992) contend that population growth poses a significant threat to food security by exerting pressure on the limited availability of food resources. They argue that the increasing population size contributes to a reduction in overall food availability.

As can be seen in Fig.1, Morocco has experienced significant demographic changes since gaining independence. In 1956, at the time of its political independence, the country's total population stood slightly above 10 million. Over the span of 60 years, it tripled, reaching 36.9 million in 2020 (Fig 1). Throughout this period, the Moroccan population witnessed an increase of nearly 4 million individuals per decade. However, the natural growth rate has gradually declined, reaching 1.21% in 2020, compared to 3.23%, 2.72%, and 1.60% in 1960, 1970, and 2010, respectively. This downward trend is expected to persist in the upcoming decades, with the natural growth rate projected to decline to 0.41% by 2050, as indicated by the intermediate variant of United Nations projections (WB, 2023).

Fig. 1. Population in Morocco 1960-2020



Source: population data for 1960-2020 from the World Bank open database 2023

2.2 Water and land availability

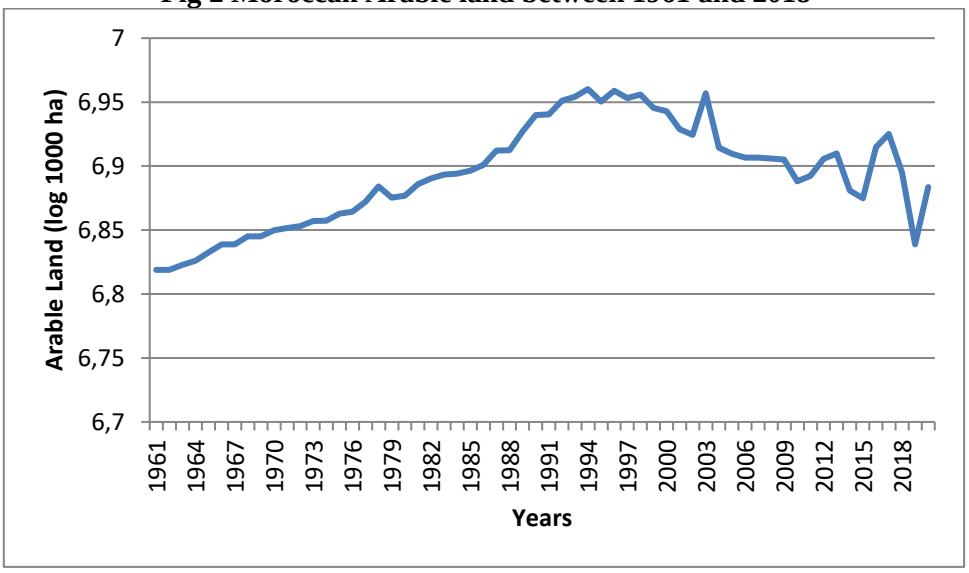
According to the World Resources Institute (WRI) report (Mason et al., 2019), Morocco is classified as one of the countries facing high water stress. Morocco is the 23rd country

globally (Hofste et al., 2019) and is the second most vulnerable country in North Africa, following closely behind Libya, which holds the sixth position. The impact of climate change is expected to exacerbate water scarcity by reducing water supply while demand continues to rise, thereby intensifying water stress. By 2030, water supply per capita in Morocco could decrease to 500 m3/year, compared to the current level of 730 m3/year.

As competition for increasingly scarce water resources intensifies, there is a significant risk of adverse effects. Urban water demand in most major Moroccan cities is projected to rise by 60-100% by 2050. This heightened demand, coupled with water crises, could pose a serious threat to the agricultural sector's access to water, resulting in disruptions to rural livelihoods and incomes (Gleick and Iceland, 2018). Multiple reports and studies on climate projections reinforce the notion that these phenomena will intensify throughout the 21st century, leading to further degradation of natural resources, particularly water scarcity.

Arable land refers to all land ready to be ploughed and cultivated. Their increasing disappearance and soil impoverishment are at the root of a growing ecological and food crisis. International organizations are trying to reverse the process and propose alternative models of cultivation to feed the planet.

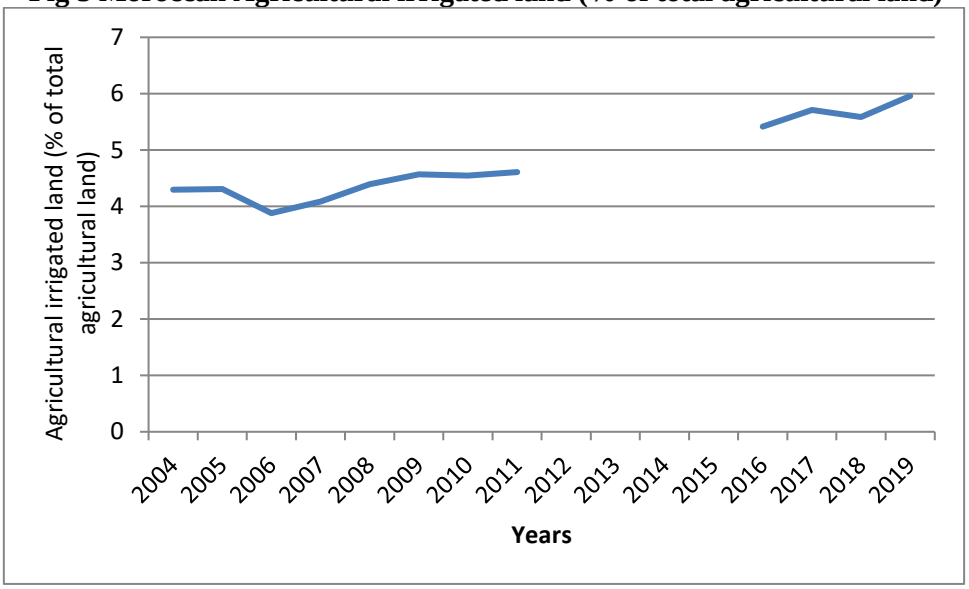
Fig 2 Moroccan Arable land between 1961 and 2018



Source: population data for 2004-2019 from the World Bank open database 2023

Figure 2 depicts the arable land area in Morocco and Figure 3 represents the land area equipped for irrigation during the period from 2004 to 2019. These figures indicate a notable increase in investment in irrigation. According to various sources, including the Desertification Indicator System for Mediterranean Europe (no date) and Siebert et al. (2015), highlight that droughts can lead to the temporary or permanent abandonment of irrigated land. The measurement of actual irrigation water used within these equipped areas provides insight into the availability and utilization, or lack thereof, of irrigation water resources, influenced by various factors.

Fig 3 Moroccan Agricultural irrigated land (% of total agricultural land)



Source: population data for 2004-2019 from the World Bank open database 2023

The development of irrigation has always been one of the fundamental options of Morocco's agricultural and rural policy, and has been since the 1960s, when the objective of one million irrigated hectares by the year 2000 was set. The irrigation sector, crucial for the national economy, is encountering challenges that pose a threat to sustainable agricultural development. The expansion of agricultural land has often been accompanied by unregulated irrigation practices and excessive use of mineral fertilizers. These factors can adversely affect the quality of water resources, thereby creating potential negative consequences, mainly in the form of nitrate pollution and salinity of ground and surface water, as well as soil. This pollution contributes to reducing good quality water resources and accentuates the imbalance in Morocco's water sector (AHRAM, 2010). Irrigation has thus played an increasingly important role in contributing to food security, and in meeting Morocco's export needs.

In many agricultural regions of Morocco, irrigation is an essential factor in boosting agricultural productivity and securing higher incomes for farmers. However, water scarcity, which is intensifying with climate change, is a real challenge for Moroccan farmers, most of whom rely heavily on river water to irrigate their land. Indeed, irrigated agriculture has become an essential component of Morocco's economy, generating wealth and creating jobs. Irrigated agriculture in Morocco accounts for only 15% of cultivated land. However, it contributes almost 45% of agricultural value added. This contribution is most significant in years of drought, when production in Bour areas is severely affected. It should also be pointed out that the irrigated sector contributes 99% of sugar production, 82% of market garden production, 100% of citrus fruits, 75% of fodder and 75% of milk. The sector provides almost 120 million working days a year, or over a million jobs, 250,000 of which are permanent.

Through irrigation, Morocco has seen an improvement in farmers' incomes. In fact, their incomes have been multiplied by 5 or even 13 times, depending on the perimeter, and access to other communal public services has been improved. Given its importance, the Constitution

obliges the public authorities to mobilize the necessary resources to ensure that all citizens have access to water, enjoy a healthy environment and benefit from sustainable development. But access to water is no easy matter in a country under water stress.

2.3 Food production trends

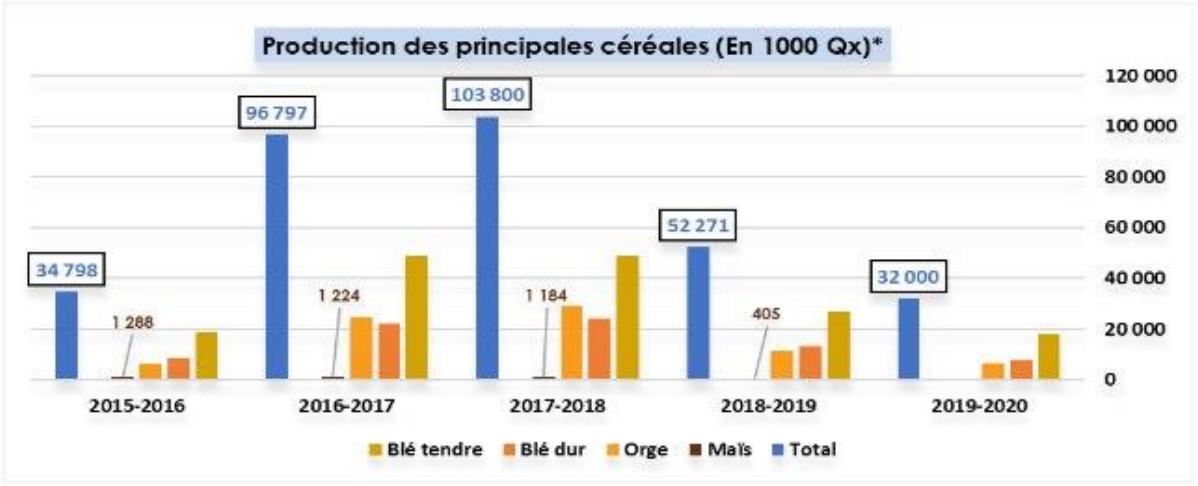
In this section, we present food production trends over time for the country's main staple crops. Figure 4 shows trends in production of the main agricultural crops in Morocco between 2015 and 202, by product (in tonnes), demonstrating that the cereals sector is one of the main agricultural production sectors in Morocco and has a significant socio-economic weight Over the years, Morocco has made significant efforts to establish itself as the world's leading exporter of high-quality fresh fruits and vegetables.

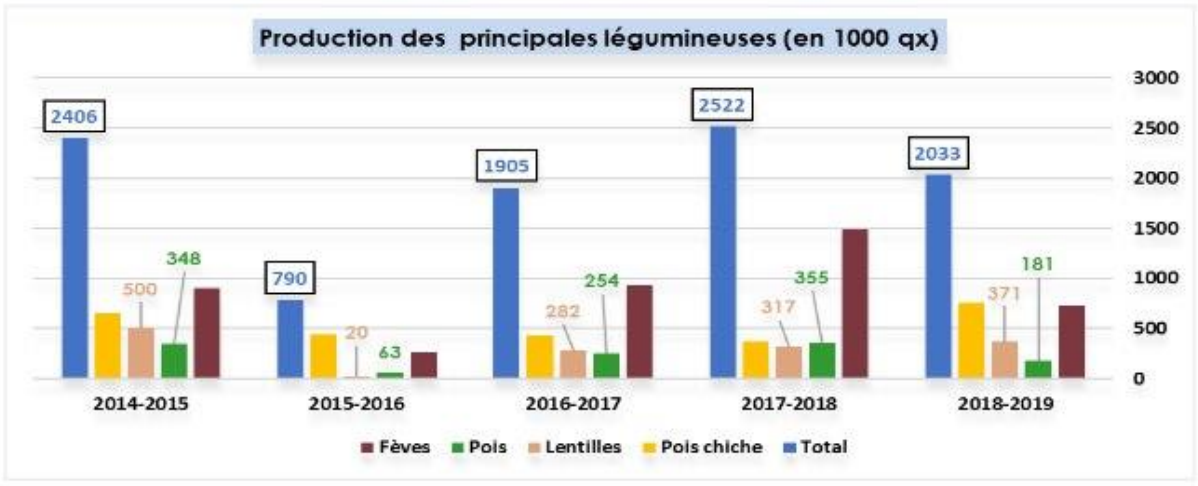
The country has witnessed substantial growth in fresh produce exports, primarily driven by fruit exports, which account for approximately 95% of the total. Presently, Morocco boasts a diverse range of agricultural exports, including over 50 varieties of fruits and vegetables. The country's export portfolio includes citrus fruits, tomatoes, green beans, zucchini, pumpkins, berries, and many others. Among these, citrus fruits and tomatoes stand out as frontrunners in the fresh produce export market, commanding a significant share. Morocco's ability to cultivate and export a wide array of fruits and vegetables highlights its agricultural prowess and international competitiveness in the global market.

According to FAOSTAT data, Morocco's citrus production reached 2.6 million metric tons in 2019. Approximately 34% of the total citrus production is exported, while the remaining 66% is consumed domestically. In the same year, tomato production volume amounted to 1.3 million metric tons. The European Union and Russia remain the primary destinations for Morocco's fresh produce exports. However, the country is actively exploring opportunities to diversify its export markets, including supplying countries in the Middle East and the African region. This strategy aims to expand the export base and strengthen Morocco's position in the global fresh produce market.

Moroccan agricultural and food production is suffering from the protective barriers imposed by some of Morocco's trading partners, preventing full access to EU and US markets. From now on, it will be necessary to comply with standards driven by three concerns: food safety and consumer health, fair use of resources and minimization of environmental impacts, and stakeholder involvement. Although Morocco is the Maghreb country with the most favorable bioclimatic conditions (average rainfall 300 mm/year), drought is by far the most recurrent risk for crops. The influence of the Atlantic Ocean and the country's topography give rise to a multitude of microclimates, which can be divided into 4 main types: humid, sub-humid, semi-arid and arid, the last two of which have tended to expand in recent decades.

Fig 4 Production of major agricultural crops in Morocco 2015-2020, by product (in 1000 Qx)





Source : ONICL, 2020

According to the thresholds defined by the United Nations, Morocco is one of the 45 countries in the world suffering from water shortages. Moroccan agriculture is also characterized by the scarcity of productive land and the fragmentation of farms. Excluding rangelands from its definition, the country's useful agricultural area (UAA) amounts to 8.7Mha (12% of the country's total surface area), with rangelands occupying 30Mha. Rangelands are found throughout the country, but are more widespread in arid zones. They play an important role in feeding livestock (more than 30% of the fodder balance) and in maintaining the ecological balance (habitat for numerous wild animal species, protection against water and wind erosion), but monitoring shows that they are subject to heavy exploitation, which is at the root of their degradation. Sheets of esparto grass, a herbaceous plant that can be used to manufacture high-quality printing paper, represent 3.3Mha; forest areas, which only represent 5.7Mha, are shrinking as a result of land clearance.

The agricultural and agrifood sectors play an essential role in the Moroccan economy (OECD, 2020). Including fisheries and forestry, agriculture accounts for around 13% of GDP, i.e. more than most other Southern Mediterranean (MED) countries. Between 2008 and 2017, this share grew by an average of 7%, well above the 3.9% growth in Moroccan GDP over the same period (Harbouze et al., 2019). While agricultural employment in Morocco is the highest in the MED region (33%), poverty rates are higher than the national average in regions with a high share of agricultural GDP (World Bank, 2017). Informal employment is largely dominant in the sector. Implementing measures towards the formalization of employment could strongly affect growth, productivity and employment in the sector and within the overall economy.

3. The Prospective Influence of Climate Change on Water Resources and Crop Yields in Morocco

The first signs of climate change in the Kingdom of Morocco are already visible, in the form of disrupted average rainfall patterns and rising average temperatures. This change could have an impact on natural resources, ecosystems and agricultural production (plant and animal). Aware of these socio-economic repercussions, Morocco has adopted a voluntary, integrated, participatory and responsible approach to adaptation and mitigation, which is one of the major pillars of its National Sustainable Development Strategy (Et-Touile, H, & Fatima, A; 2021). As Morocco's biggest consumer of water, agriculture has a negative impact on the quality of the resource. And the water it uses is considerably wasted. In countries threatened by water scarcity, such as Morocco, producing more with less water seems to be the major challenge of the coming decades. Agriculture can be held both responsible for and a victim of water scarcity. But in any case, of all economic sectors, agriculture is the one that is 256 indeed the most sensitive to water issues. However, water requirements to cover agricultural and industrial demand are worryingly high in relation to the volume of water currently available. This situation calls for urgent action to deal with the water shortage threatening our country. Given that delayed reforms can only exacerbate our water deficit.

According to a recent study conducted by Et-Touile and ARIB (2021), compelling evidence indicates that climate variations in Morocco have undergone significant changes and are projected to continue evolving in the future. Their research suggests that climate change, encompassing temperature fluctuations, alterations in rainfall patterns, and changes in arable land availability, collectively impact crop yields and subsequently affect the agricultural GDP of the country. These findings highlight the crucial link between climate change and agricultural productivity in Morocco. The authors suggest that, in the long term, a 1% increase in temperature leads to a 3.14% reduction in the value added of the agricultural sector in the short term, and a 5% reduction in the long term.

Water scarcity could affect almost every aspect of Morocco's future socio-economic development. Morocco is one of the most water-poor countries in the world, and is rapidly approaching the absolute water shortage threshold of 500 m3 per person per year. The increasing incidence and severity of drought is already a major source of macroeconomic volatility and a threat to national food security. In a longer-term perspective, reduced water availability and lower agricultural yields due to climate change could reduce GDP by up to

6.5%. Rain-fed agriculture (bour) is particularly vulnerable to droughts and water shortages: while it still accounts for 80% of the country's cultivated area and employs the majority of farm workers, climate-induced changes (water availability and crop yields) on rain-fed agriculture could lead to the rural exodus of 1.9 million Moroccans (or 5.4% of the total population) by 2050.

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4. Recommendations

4.1 Increasing water supply

The issue of water demand, as opposed to supply in the context of water management, raises important questions that require particular attention in water-limited regions such as Morocco. Over the last century, particularly in the Mediterranean region and especially in Morocco, vast water supply projects have been undertaken. These projects have involved the construction of large reservoirs, long-distance water transfers and the extraction of fossil and underground resources. However, these projects face various social and environmental constraints, requiring a balance between supply and demand management. This balance can be achieved by minimizing losses, improving efficiency and implementing protective measures (Yuan et al., 2003). By improving efficiency, for example by reducing losses and wastage, we can strive to stabilize the demand for water in our country. This is all the more important as water scarcity problems are set to persist over the coming decades. Other approaches are technically feasible and important for ensuring a sufficient supply of water for irrigation, such as water harvesting, which mainly refers to the capture and storage of rainwater for on-site reuse, instead of allowing it to runoff. This method, as highlighted by Liang and van Dijk (2011), emphasizes the importance of collecting and storing rainwater to maximize its utilization for irrigation and other purposes. Additionally, another strategy involves the reuse of treated wastewater for irrigation and various other applications. This approach helps conserve freshwater resources and provides an alternative water source for agricultural activities.

4.2 Improving irrigation efficiency

Crucial for food security, important for the development of the national and rural economy, a determining factor in resilience to climate change, significant for the promotion of rural employment, irrigation has always been at the heart of public authorities' concerns. For decades, however, irrigated agriculture has faced significant challenges due to the scarcity of water resources. This scarcity has resulted from the compounding impact of consecutive and prolonged droughts and the growing demand for water from various economic sectors. As a result, the availability of water for irrigation purposes has become increasingly limited, posing a considerable obstacle to the sustainability and productivity of agricultural activities.

There are various approaches and objectives when it comes to conserving irrigation water. These may vary depending on the scale and specific needs of the situation. For instance, a farmer might be dealing with a restricted water supply, aiming to lower energy expenses, or facing limitations in drainage capacity. To enhance irrigation efficiency at the farm level, there are several technical solutions available that can help reduce water consumption. Some examples include implementing drip irrigation systems and adopting variable-rate precision irrigation techniques. However, it's important to note that the overall performance of the irrigation system is influenced by factors such as the extent to which return flows are reused, which relies on both the hydraulic layout of the system and the effectiveness of individual irrigation units (Mateos, 2008).

Morocco is lagging far behind in wastewater reclamation. And it's time to move towards the adoption of a purification-reuse approach instead of the purification-discharge approach. Indeed, the reuse of purified wastewater (as a non-conventional resource), in particular controlled and secure reuse, has become imperative. This process relieves pressure on groundwater and helps to reduce local deficits. To meet the challenge of sustainable and competitive production, irrigated agriculture has entered a new era since the adoption of the Green Morocco Plan, an "era of rationalization and optimization of irrigation water".

4.3 Introducing entrepreneurial and innovative spirit

The theme of innovation in the agricultural and agri-food sectors sparks numerous discussions that mirror the evolving landscape of contemporary societies. These discussions challenge the conventional boundaries between North and South, rural and urban, and economic growth and social development. As a result, innovation is becoming increasingly politicized, leading to a fresh perspective and diverse approaches across various levels.

Innovation can be defined as a successful combination of three components: hardware, which refers to material equipment; software, which involves the knowledge and know-how needed to manage innovation; and orgware, this pertains to the organizational and institutional factors that shape the advancement and implementation of an innovation. (Smits, 2001). The programs generally gave priority to the "hardware" component of the innovation, i.e. the introduction of the material or technique, and not to its "software" component, i.e. the farmer's ability to master and integrate this innovation throughout his farm. Since the early 90s, with the withdrawal of the State from extension activities, almost no specific activities have been sustained to develop farmers' capacity to manage the innovations introduced.

Although Moroccan agriculture is certainly more innovative than in the 1970s and 1980s, it remains insufficiently so compared to a world agriculture that has become more innovative overall. In Morocco, innovative agriculture has begun to gain more interest in recent years among the various public and private players. Although Moroccan agriculture certainly needs financial resources to fund innovation projects, in our view, such a project can only really succeed with a certain entrepreneurial and innovative spirit. From this perspective, the current context shows that there is a real opportunity for agriculture to interact with innovation and entrepreneurship. Indeed, the Moroccan agricultural sector is fertile ground for innovative projects that are sure to change the agricultural business model, supply, practices and expertise. It is at this level that entrepreneurship and innovative enterprise, and more specifically startups, appears to be the common thread that can lead to innovative agriculture.

4.4 Promoting the role of women in the transition of agricultural models

Women play a decisive role in agriculture. The FAO estimates that women account for half of the world's food production. In many cases, they are largely responsible for land preparation, watering, harvesting, storage, processing and packaging, as well as water supply and farm administration and accounting. Added to this are the costs associated with domestic and community life.

Dominant agricultural models focusing on productivity and profits have shown their inefficiency by ignoring structural problems such as access to food, poverty and conflict. Worse still, these models jeopardize peasant farming and agro-ecological practices, which are nonetheless capable of sustainably feeding the world's population while meeting the current imperatives of combating climate change. At a time when almost 80% of the world's food comes from family farming and small-scale producers, 43% of whom are women. It's time to promote and strengthen the role of women in the transition of agricultural models to ensure food security.

Empowering women in agriculture is an essential element in building household and community resilience to food and nutrition security. Greater recognition of the role of women can have a wider effect on nutrition, strengthen rural livelihoods and generate benefits in terms of increased food production.

5. Conclusion

The aim of this paper was to assess water scarcity impacts on food production in Morocco. We analyzed national-level data concerning water resources, population growth, and available land for food production. Our investigation focused on the intersection of food production, climate change, the consequences of water scarcity, and the potential of technological advancements to ensure a sustainable food supply despite the challenges posed by limited water resources.

Our initial focus was on providing an overview of national data pertaining to population growth, water availability, land availability, and food production. We also consider the implications of climate change, which can exacerbate water scarcity and consequently impact food production. Additionally, we explored potential approaches for enhancing local water supply through the utilization of wastewater, harvested water, and flashflood water for irrigation purposes.

The main conclusion of this article is that despite the strategic importance of the agricultural sector and the progress achieved, agriculture in Morocco is still marked by a number of shortcomings. Productivity remains relatively low, and production growth has been driven more by extension onto marginal land than by intensification. Low productivity is the result of the shortcomings and dysfunctions of the agricultural policy pursued, marked by social and territorial imbalances, a deterioration in the coverage of food needs, and the fact that agriculture has become responsible for environmental degradation. Morocco's current water shortage is an urgent problem that is likely to impose major constraints on the country's economic development and food security for decades to come. The agricultural sector will be the first victim of the water shortage.

Indeed, the depletion of freshwater reserves is a worrying problem in Morocco. To address this situation, new water conservation and biotechnology technologies have been developed, as well as wastewater treatment methods for recycling and reuse. These new technologies and water sources are helping to conserve freshwater reserves and solve water scarcity problems. However, it is also important to raise awareness among individuals, communities and governments of the importance of efficient water management, conservation and sustainable use of water resources to ensure continued long-term availability.

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