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THE EFFECTS OF CLIMATE CHANGE ON THE AGRICULTURAL SECTOR IN SEMI-ARID AREAS IN MOROCCO AND THEIR ECONOMIC REPERCUSSIONS "THE CASE OF THE PHOSPHATE PLATEAU"

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ABSTRACT

This research paper aims to investigate the effects of climate change on agricultural production and to assess the economic repercussions of this phenomenon on the phosphate plateau within Morocco's semi-arid regions. To achieve these goals, we relied on various research methods and tools (technical, non-field, and field statistics), selected and processed climate-monitoring stations, identified field-sampling units, and adopted a form that was distributed to 404 families from the study sample in the Phosphate Plateau. The research results highlighted that the Phosphate Plateau has weak agricultural resources. Fallow agriculture dominates and relies on staple grain cultivation and livestock. Climate change has affected agriculture, shown by rising temperatures and frequent hot periods, especially at the start of the 20th century. Rainfall has also been irregular, with frequent dry seasons, notably in the early 1980s. These factors have harmed the agricultural sector and worsened economic conditions for the region's inhabitants. This calls for programs that support adaptation and economic development.

KEYWORDS: Climate Change, Agricultural Sector, Semi-Arid Areas, Adaptation, Economic Development.

1. INTRODUCTION

The agricultural sector is one of the most important in Morocco. It plays a key role in improving and ensuring food security. The sector also employs about 40% of the active population.

The livelihood of the population on the Phosphate Plateau heavily relies on the agricultural sector, which accounts for over 58% of their income. The primary agricultural activities include cultivating staple crops and raising livestock. Although supplementary crops are produced through occasional self-irrigation, the scope of this practice remains limited.

This agricultural system is affected by climate change, which is characterized by extreme rainfall variability, temporal irregularity in rainfall, and frequent dry seasons. The main result of all these disturbances is the decline of productivity, cultivated area, and production in many agricultural seasons, and thus the limited volume of local production. Based on the limited amount of annual rainfall, rain-fed agriculture occupies about 98% of the arable area, compared to 83% at the national level. This great connection with inter-annual changes for precipitation makes the agricultural system fragile and unable to stabilize the foundations of a rural economy based on the Phosphate Plateau.

In the face of these challenges, a set of agricultural strategies and projects was assigned to develop rural areas and advance the rural world, but all interventions in these areas remained fragmented, not comprehensive of the field, and did not achieve the desired development goals.

1.1. Research Motives

This topic is considered one of the most important modern studies that warrants attention and rigorous scientific investigation. This involves, firstly, understanding the agricultural characteristics and strengths and weaknesses of the phosphate plateau, and secondly, highlighting and analysing the impact of climate change on the agricultural sector, given its fundamental economic role for the region's inhabitants. Consequently, these climate changes pose a significant obstacle to agricultural exploitation, particularly in light of the limited government intervention through effective programs and projects for agricultural development in this area.

Therefore, it is essential to conduct a comprehensive scientific study that considers geographical dimensions and integrates findings into the economic and social development plans and hydro-agricultural strategies undertaken by the state.

1.2. Study Area

Naturally, the phosphate plateau is known as the Inner Mesita within the Atlantic plateaus and plains. It is part of the Central Plateau, which includes the plateaus of Haute Chaouia and Ouardigha It extends over an area estimated at 9,000 km2, in which the height ranges from about 850 m in the area of Khouribga neighborhood to 450 m in the Settat neighborhood and ends in the north and west direction (Lower Chaouia) with a set of rims with a height range of up to 150 m.

It is composed of well-developed erosional surfaces composed mainly of limestone and erosion, and climatically it belongs to semi-arid areas controlled by continental factors and elevation, where precipitation does not exceed 350 mm, which has made its water resources scarce at the level of surface runoff, and the weakness and depth of subterranean bad recharge.

It is geographically located in the northwest of the national territory between longitudes 6.54 and 7.25 west and latitudes 32.53. 33.50 North, It brings together parts of Settat Governorate in the Casablanca-Settat region, and the governorates of Khouribga, Fkih Ben Saleh, and Beni Mellal in the Beni Mellal-Khenifra region within the framework of the advanced regional division of 2015, (fig.1) after unifying them into one region "Chaouia-Ouardigha".

The Phosphate Plateau has long been a sought-after location due to its prime position along the main corridor connecting northern and southern Morocco, and the abundance of its productive resources. Throughout ancient, modern, and contemporary history, humans have settled in the area, driven by the desire to rebuild and make use of its valuable soil resources.

The Phosphate Plateau includes about 82,370 families out of 101,867 families in both the Settat and Khouribga provinces during the 2014 census. The rural population in the Settat province was about 416,550, and in the Khouribga province, about 164,614 people in 2014.

The Phosphate Plateau is renowned for its agricultural features, which are defined by vast tracts of fallow land. These lands are primarily used for growing light to medium grains, including wheat and barley, and for raising livestock such as sheep, cows, and goats. Grazing is a predominant activity carried out on these lands, and this practice dates back to the marinid era.

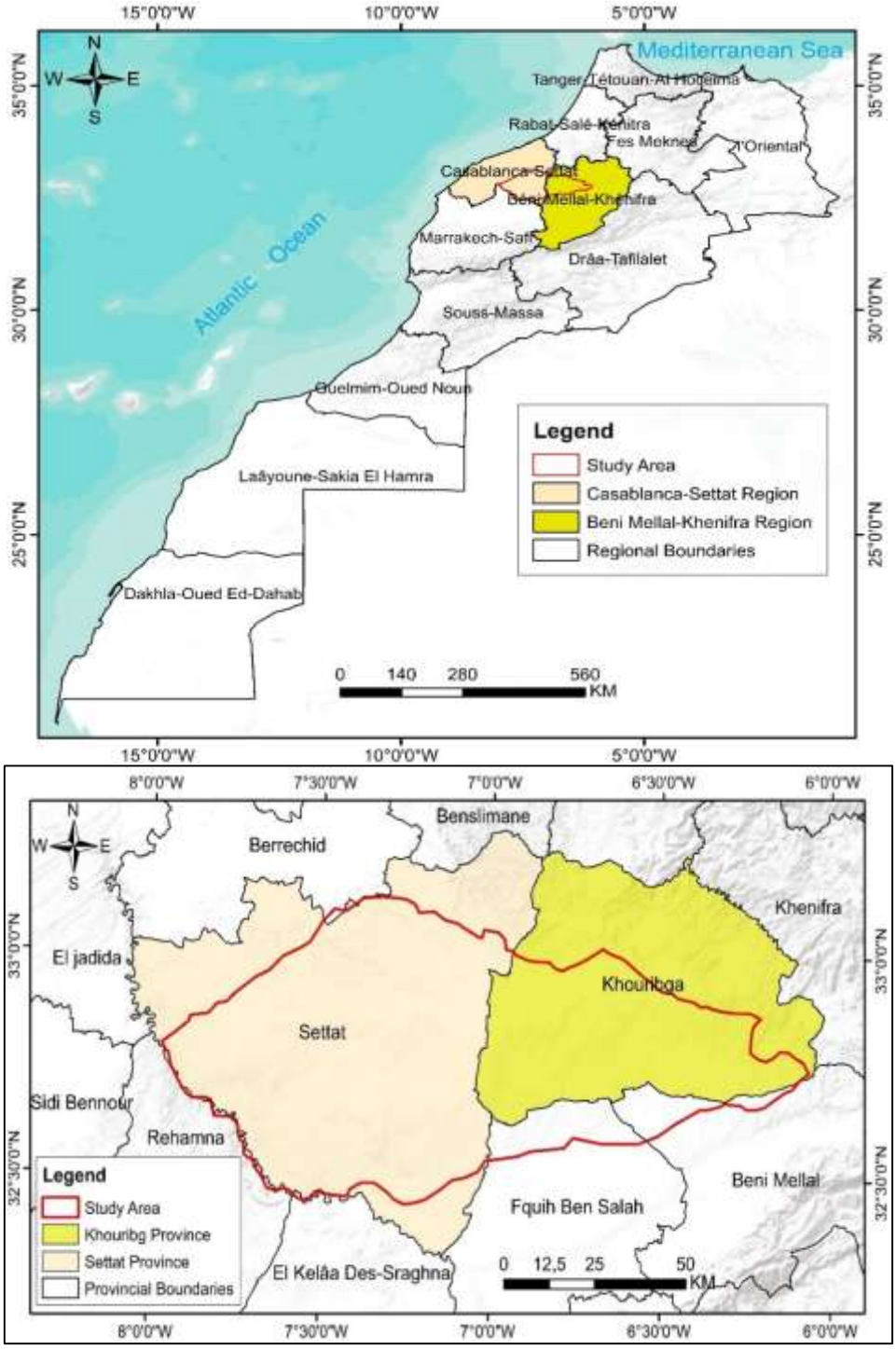

Figure 1: The Location of the Phosphate Plateau within the National and Regional Territory.

1.3. Research Problem

The Phosphate Plateau is located in a semi-arid area, which means that natural resources are limited and the agricultural sector is vulnerable. Climate changes, such as higher temperatures, lower precipitation, and irregular weather patterns, have only worsened this situation. The agricultural sector is the main source of income for the population, and its struggles have had negative impacts on the economic and social conditions of the area. The development policies are insufficient to support the population and help them adapt to climate change. Initiatives like the Rural Development Plan and the Green Morocco Generation Green Plan are working towards achieving agricultural and rural

development, but the region is still facing marginalization and exclusion in economic and social plans and local development programs.

So, how have climate changes affected the agricultural sector in the phosphate plateau? What are their economic repercussions, and what are the most important adaptation and agricultural development measures?

1.4. Study Hypotheses

Climate change, through increased temperature, fluctuations in annual rainfall, its irregularity, and the frequency of droughts, contributes to a decline in agricultural production and practices, further exacerbating the economic hardship of the region's inhabitants.

2. SOURCES AND METHODOLOGY

Bibliographic Research: This work is based on bibliographic studies that address the subject and field of the study.

Fieldwork: Geographical research is based on the field as a ground for measurement and an embodiment of natural and human interactions. This is done through field surveys as the first direct contact to examine the field. The data is based on qualitative and quantitative statistical data collected from a range of relevant departments and agencies, such as the Regional Directorate of Agriculture, agricultural extension offices, meteorological directorates, and data from rural local authorities. This data was classified, processed, and corrected, and the consistency of the monitoring station data was analysed.

To process and analyse this climate data, we relied on a set of statistical methods, such as the temperature deviation method and the uniform precipitation index, to determine the wet and dry seasons and their degree of severity according to the following formula:

$$Sp_i = \frac{Pi - Pm}{\alpha}.$$

Where Pi is the annual rainfall amount, Pm is the average annual rainfall for the statistical series, and α is the standard deviation of the statistical series.

Field Form: Prior to the distribution of the form, approximately 54 rural territorial communities in the phosphate plateau (Fig.2 And Table. 1) were identified, based on a matrix that includes five indicators of agricultural production (topography, soil, climate, water resources and area of main grains), in order to classify these groups in the phosphate plateau according to the evaluation index.

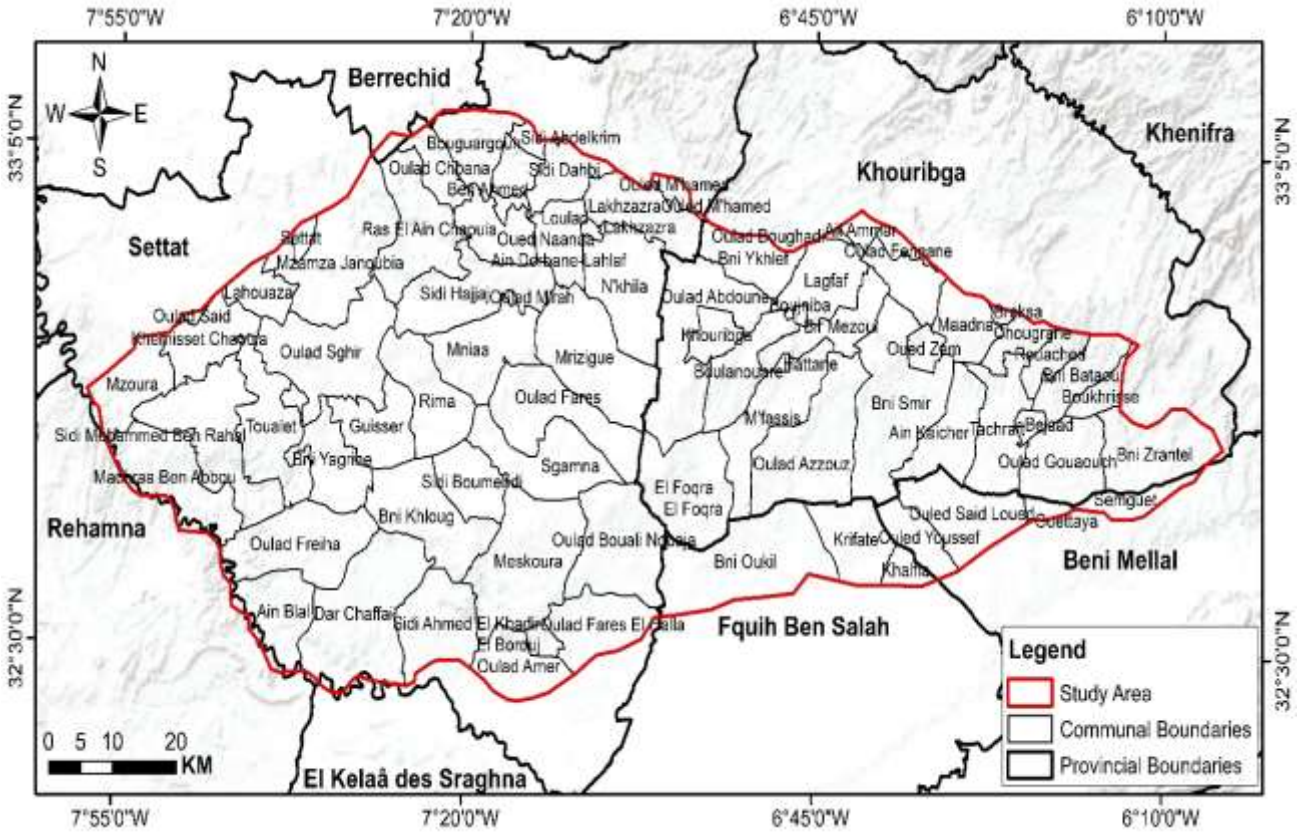

Figure 2: Distribution of the Marginalized Territorial Communities in the Phosphate Plateau.

Table 1: Matrix of Indicators and Characteristics of Agricultural Production in the Phosphate Plateau

Indicators	Characteristics	Rating rates
Topography	undulating topography	2
	flat topography	1
Soil fertility	more than 40%	3
	Between 40 and 20%	2
	Less than 20%	1
climatic characteristics	more than mm330	3
	Between 333 and 300 mm	2
	Less than 300	1
Water resources	Between 20 and 30 m	3
	Between 30 and 40 m	2
	More than 40 m	1
Main grain area	Less than 70 %	3
	Between 70 and 80 %	2
	more than 80%	1

Based on these indicators, the regional communities included in the study were divided into groups to define and draw spatial sampling units, according to specific rules.

This process revealed differences in agricultural potential, within the phosphate plateau, where there are weak qualifications in the center of the plateau and towards the south (Fig.3), while there are important qualifications in the north and northwest, then east towards the Tadla plain.

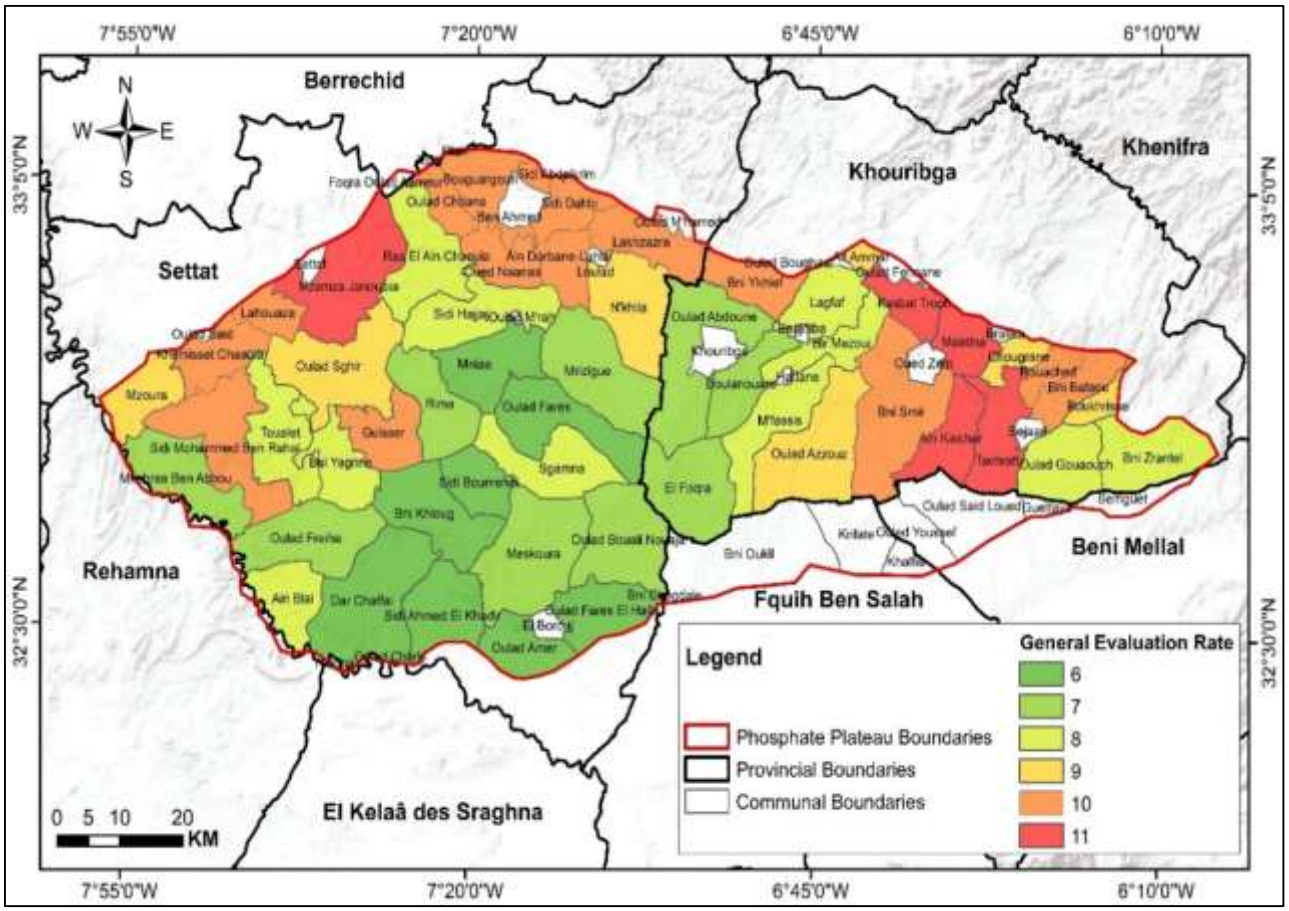

Figure 3: Classification of Phosphate Plateau Groups According to Average Overall Rating.

Rural communities in the phosphate plateaus were categorized and ranked according to the importance and assessment of their agricultural capabilities into groups, which facilitated access to field sampling units.

These groups thus formed the basis for our

selection of field sampling units, with each selected group representing other groups with the same assessment score.

The selection of the studied spatial sampling units was intentional, guided by the logic of spatial spacing and diversity to ensure broad and comprehensive coverage of the area, while adhering to certain fundamental selection criteria, including:

- A community must be located entirely within the phosphate plateau.
- A community must be selected from among those spatially concentrated and possessing a similar growth rate.
- Spatial spacing must be ensured.

Based on the previous steps, six cases were selected for study (Fig 4). This process will enable us to compare groups with significant, intermediate, and weak agricultural indicators.

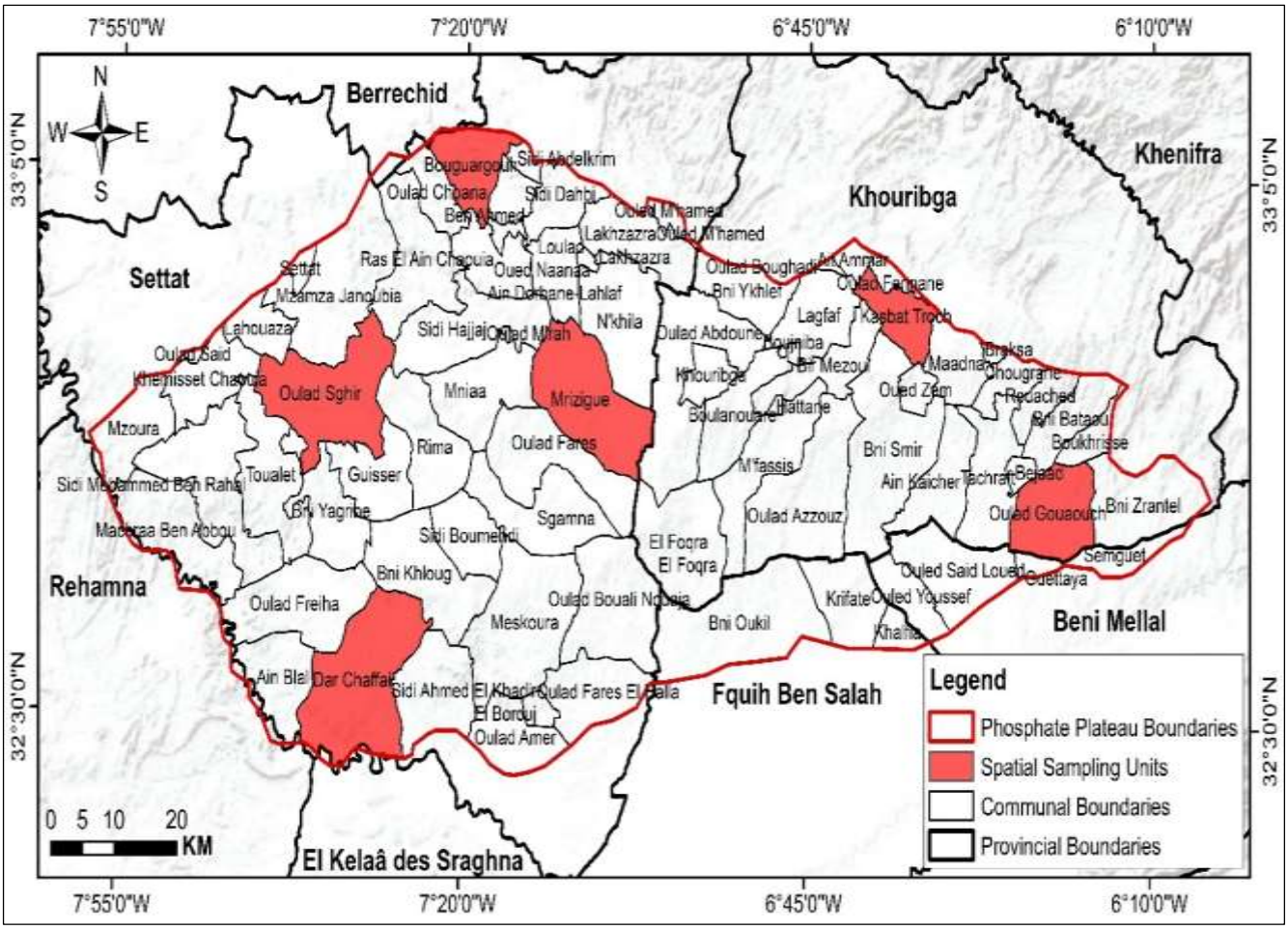

Figure 4: Shows the Distribution of Spatial Sampling Units in the Phosphate Plateau.

After identifying the field sample units, the next step is to choose the type of sample, which is the farmer as a socio-economic unit for field sampling, and to determine its size and distribution among these units based on some assumptions necessary to obtain accurate and scientific results.

Error rate 5%.

-The percentage of phenomena under investigation present in the sample is 50%, and the percentage of their absence is 50%.

Apply the following equation.

Approximate sample size: $\frac{50\times 50\times(2)^2}{(5)^2}$

Approximate sample size: $\frac{4\times 2500}{25} = 400$

Actual sample size = 0 .99

$$\frac{400}{0;99} = \mathbf{404.04}$$

Therefore, the appropriate sample size that allows the assumptions to be met is 404 households as a socioeconomic sampling unit out of 82,370 households in the Phosphate Plateau, which will be drawn and distributed to the groups by the optimal stratified drawing method.

Based on the following statistical process $n_i = \frac{N}{\sum N_i \times \sigma_i} \times N_i$

Whereas n_i is the desired layer sample size, N is

the sample size, N_i is the field sampling frame, and σi the standard deviation.

According to this process, we arrive at the following rate: 46436767

The next step is to use the constant coefficient extracted by the sample size, which is equal to 404 divided by the sum of the deviations in the households, as follows:

Constant coefficient= $\frac{404}{46436767}$ =0.00000870011

Finally, we obtain the sample size distribution in each group by applying the following formula: constant coefficient times total number of households times standard deviation for each territorial community (Table 2).

Thus, the questionnaires are distributed according to this selected sample using the field sampling units.

The questionnaire is a tool for collecting non-field data. As a procedural translation of the research variables, its questions, which frame the topic, revolve around understanding agricultural exploitation patterns, determining the impact of climate change on water resources and agricultural production, how this has affected the economic and social conditions of the population, and assessing the effectiveness of the strategies adopted for adaptation and rural development in the phosphate plateau.

We also relied on methods and programs (Excel) and (SPSS) to analyse the data and clarify its meaning, and ArcGIS 10.3 for mapping. This is done by adopting a systematic approach that allows various variables to be linked to each other.

We adopted the systematic approach, which is considered one of the modern approaches in geography. This approach allows for the study and analysis of various macro and micro variables, linking them within a coherent framework from the general to the specific. It is based on other auxiliary approaches such as the holistic inductive approach, the historical-analytical approach, and the statistical approach.

Table 2: Distribution of the Number of Families Withdrawn from the Studied Spatial Units in the Year 2021.

Rural territorial community	**Number of families Ni**	**Standard deviation**	**Deviance times number of families**	**Number of withdrawn families**
Kasbat Trouch	1624	99	160776	74
Bouguargouh	1543	18	27774	40
Oulad Sghir	2528	1003	2535584	55
Oulad Gouaouch	577	948	546996	102
Mrisigue	1430	95	135850	58
Dar Chaffai	2913	1388	4043244	75
Field review framework	**Ni = 10615**		Rate **=46436767**	**404**
Sample size	**N= 82,370**			

3. RESULTS

3.1. Manifestations of Climate Change in the Phosphate Plateau and Their Effects on the Agricultural Sector

The phosphate plateau has witnessed climatic changes in connection with general changes, manifested in an increase in temperature, a decrease in rainfall and its irregularity, and the frequency of drought seasons, which have affected the agricultural sector.

3.2. The Tendency of Heat to Rise

The phosphate plateau has experienced temperature instability and deviation from the average in many seasons, and it also experiences unusual increases in some moderate months, such as the spring months of March and April and the autumn months of September and October.

The period between 1980 and 2000 was characterized by a kind of stability and was marked by coldness. The temperature fell below the average in many seasons, such as 1993-1994, 1995-1996, 1996-1997, and 1998-1999, as the latter recorded a deviation from the average of -1 degree at the studied stations (Fig. 5).

While temperatures after this period showed a tendency to rise, and the intensity of hot seasons increased, exceeding three ideal years, as occurred between 2003-2006, 2009-2011, and 2013-2017, and then the period between 2018- 2022, where average deviations ranging between 0.3 and 1.5 degrees Celsius were recorded at the studied stations. This rise in temperature affects the amount of transpiration and atmospheric humidity, which ranges between 50% and 90%, negatively impacting agricultural crops.

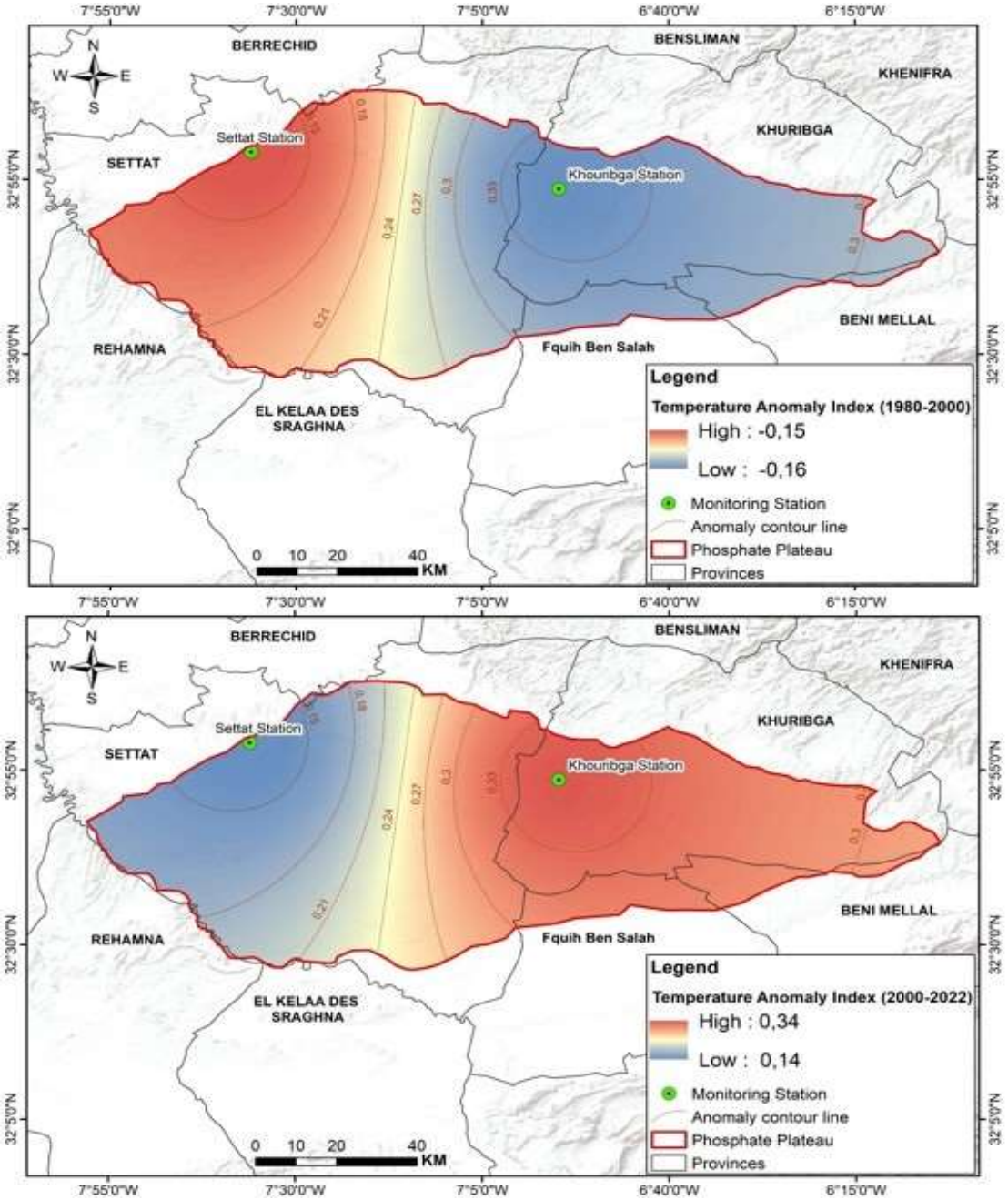

Figure 5: Annual Evolution of Temperature Deviation from the Average for the Period Between 1980 and 2019 at the Phosphate Plateau Stations.

3.2.1. Frequent Seasons of Low Humidity and Moderate Drought

Rainfall patterns in the phosphate plateaus are characterized by sharp fluctuations from year to year, with frequent wet and dry seasons, though the dry season is predominant. These areas have experienced periods of high rainfall, most notably during the 1960s and 1970s, encompassing the seasons of 1962-1963, 1970-1971, and 1977-1978. This was followed by the seasons of 1978-1979, 1987-1988, 1994-1995, and 1995-1996, which affected the entire country of Morocco. The 2009-2010 season experienced an excess of 2.86 mm of rainfall, with the average excess ranging from 1.15 to 1.69 mm. While the 1960–1961, 1973–1974, 1977–1978, 2008–2009, and 2014–2015 seasons experienced periods of moderate humidity, rainfall deviated from the average by 1.08–1.44 mm across the stations, confirming the prevalence of periods of low humidity, where the average deviation was limited to between 0.99 and -0.99 mm.

While periods of drought became more frequent and severe starting in the 1980s, the studied stations experienced periods of moderate drought during the

following years: 1980-1983, 1998-2000, 2004-2008, and 2013-2016. Rainfall averages varied between -1.13 and -1.46 mm across the stations.

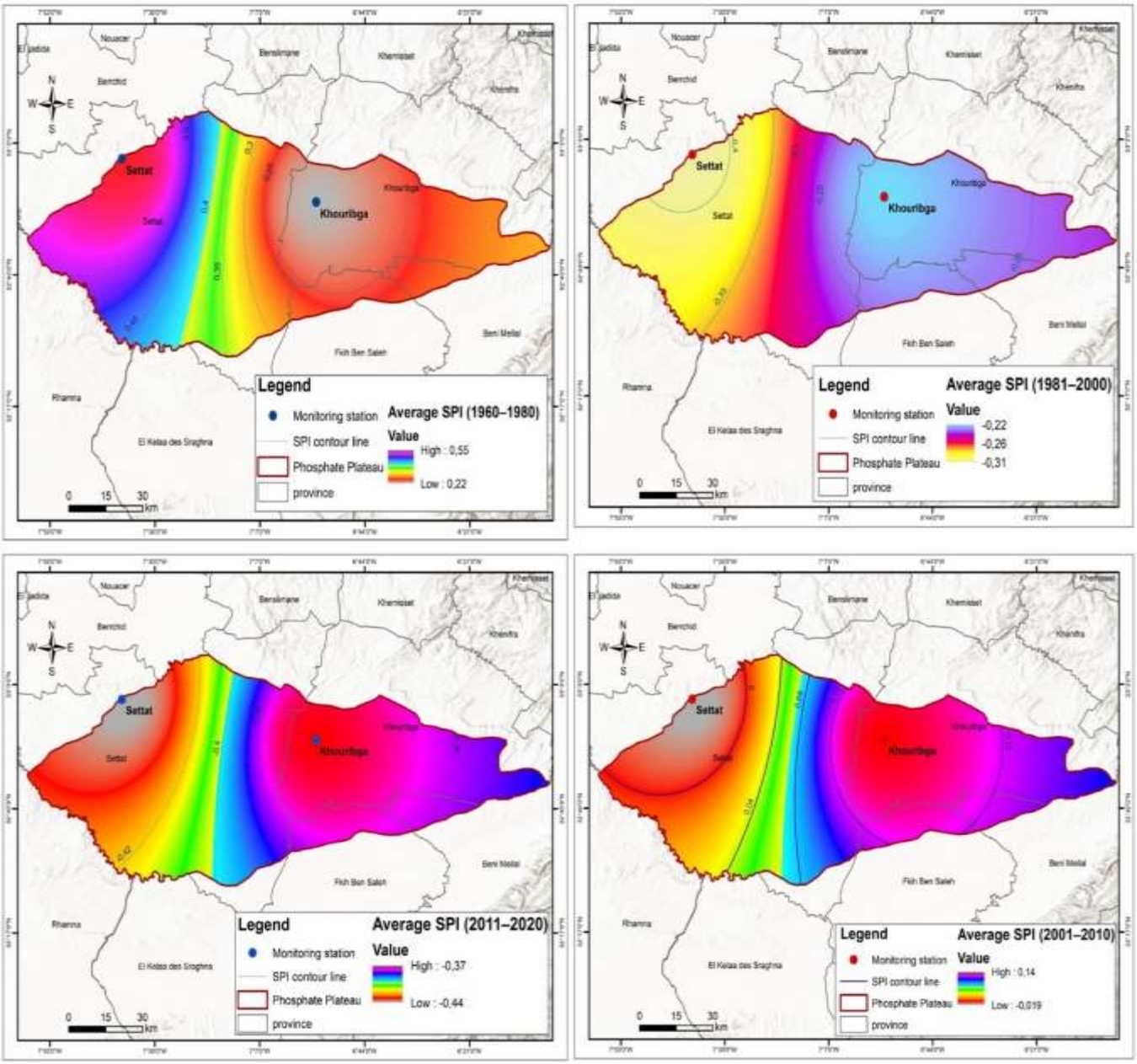

Figure 6: The Interannual Evolution of the Deviation of Precipitation from the Average During the Period Extending Between 1960 and 2021.

Severe drought periods with rainfall deficits ranging from -1 to -1.92 mm also occurred, including the seasons of 1982-1983, 1992-1993, and 1995-1994, as well as the periods between 1998 and 2003, 2015-2016, and 2018-2019. It is also noted that there is a difference between the stations in the degree of rainfall deficit during these observed periods, as it is lower at the Settat station during the period 1960-1980 than at the Khouribga station, and it increases during the rest of the periods, unlike the Khouribga station.

3.2.2. The Impact of Climate Change on the Agricultural Sector

Water is the basis of a plant's existence. Its growth in all biological stages depends on the amount of water available. Water is necessary for the plant on several levels, as it is included in the composition of its cells at rates ranging between 10 and 95% of the plant's composition. (Fadl Allah Abdul Latif Al-Jami,

1983) Cereals, because they are annual plants, are the crops most affected by climate fluctuations and sensitive to their temporal distribution.

There is a close and direct relationship between the amount of rainfall and the production of the main grains (Fig. 7), as this rainfall is characterized by extreme variability that leads to disruptions and instability in production during the period from 2000 to 2019.

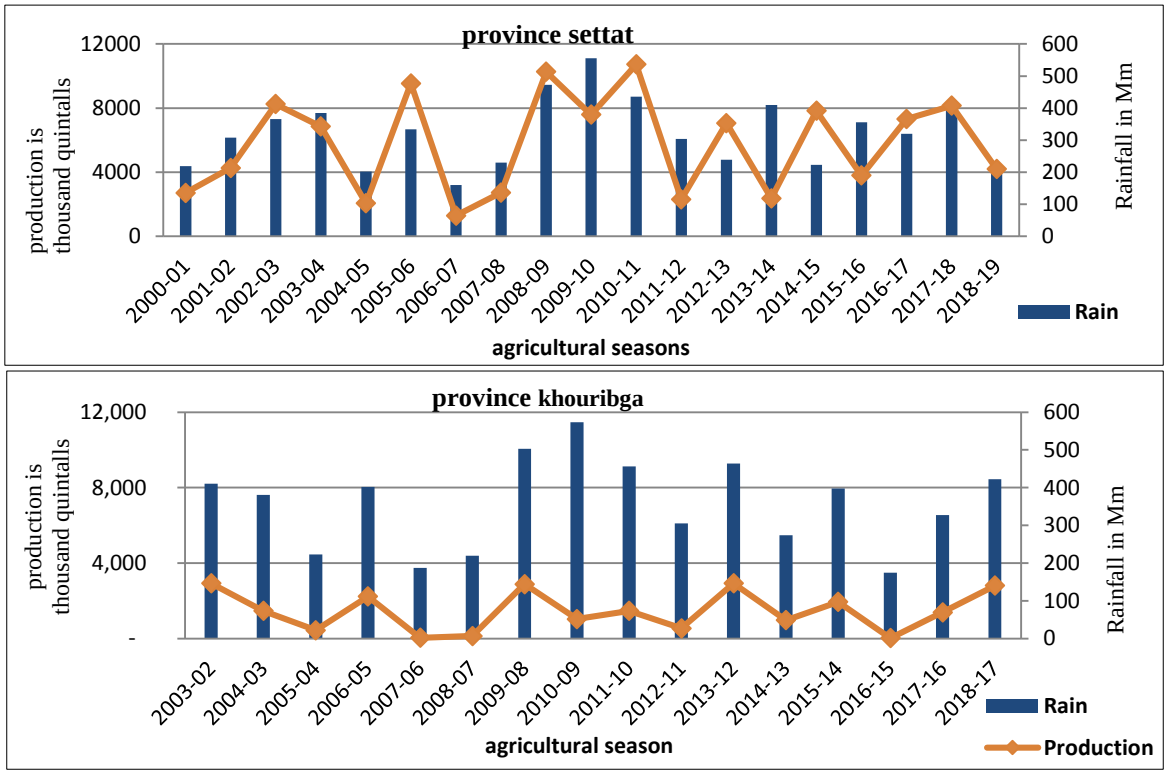

Figure 7: Fluctuation of Agricultural Production in the Phosphate Plateau During the Period Between 2000 and 2019.

Production increased during wet and rainy seasons, such as the seasons of (2002-2003, 2004-2003, 2008-2009, 2009-2010, 2010-2011, 2016-2017 and 2017-2018) to between 7,000 and 11,000 thousand quintals with a productivity exceeding 20 quintals/hectare in the Settat region, and to between 1,000 and 3,000 thousand quintals in the Khouribga region with a productivity exceeding 13 quintals/hectare, where the amount of rainfall in most seasons exceeded 350 mm with a rainfall surplus exceeding 0.50 mm. The rainfall was characterized by its regularity according to the stages of the agricultural cycle. While production declined during dry seasons, such as 2000-2001, 2001-2002, 2004-2005, 2006-2007, 2008-2009, 2011-2012, and 2018-2019, it fell to less than 2,500 quintals with a yield of less than 7 quintals/hectare in the Settat region, and to between 400,000 and 31,000 quintals with a yield of less than 4 quintals/hectare in the Khouribga region. This was due to low and irregular rainfall, which did not exceed 220 mm with a deficit of more than 1 mm, in addition to high temperatures and increased evaporation, leading to soil and crop desiccation. The disparity in production between the two regions is attributed to the fact that the area of arable land in the Settat region is larger than that in the Khouribga region

The regularity of rainfall contributes to increased agricultural production, along with an increase in cultivated area and the development of the use of technologies, while it declines due to irregularity in time according to the biological stages of crops, as witnessed in the region during some recent seasons, with its dryness during the germination stage and the beginning.

Livestock farming also experiences development in relation to climate conditions and the nature of the agricultural season, as it witnessed an increase during some seasons, such as the 1995-1996, 2007-2008 and 2009-2010 seasons, where the last recorded about 1,304,000 head in the Settat region and 1,161,000 head in the Khouribga region, representing a percentage of more than 80%, as these seasons were characterized by high humidity with rainfall

amounting to more than 400 mm (High Commission for Planning, Regional Bulletins, 2009-2019).

While the number of livestock heads decreased during some drought seasons, such as the 2013-2014 season, to 1,230,000 heads in the Settat region and about 799700 heads in the Khouribga region, with a change rate of up to 31%, compared to the previous season, 2009-2010.

3.3. Economic Repercussions and Some Adaptation and Agricultural Development Measures in the Phosphate Plateau

3.3.1. A Fragile Economic Situation Dependent on Climate-Related Agricultural Activity

Rural communities in the phosphate plateau face the challenge of climate change due to their heavy reliance on dryland farming of staple grains and livestock breeding, in the absence of irrigation practices, dwindling groundwater resources, poor management of communal lands, inadequate agricultural structuring and material and technical support for farmers, and a lack of investment in industrial units to drive local development, along with inadequate infrastructure and facilities, leading to several economic and social challenges.

Individual income and weak marketing do not meet the basic needs of families in the phosphate plateau The income of the population from agricultural production is linked to the structure and productivity of the agricultural holding, the number of livestock, and reliance on other crops of material value. The average per capita income for households is between 10,000 and 20,000 Moroccan dirhams per year, representing 48.3%, followed by less than 10,000 dirhams at 24.2%, while income exceeding 40,000 dirhams per year constitutes 5% of the total surveyed units. This percentage is higher in the commune of Oulad Couaouch, due to the presence of large farmers who own vast tracts of land and rely on fattening a significant number of cattle and sheep. It is lower in the communes of Dar Chaffai and Mrizigue, and nonexistent in the remaining communes due to limited agricultural resources and capabilities (Fig. 8).

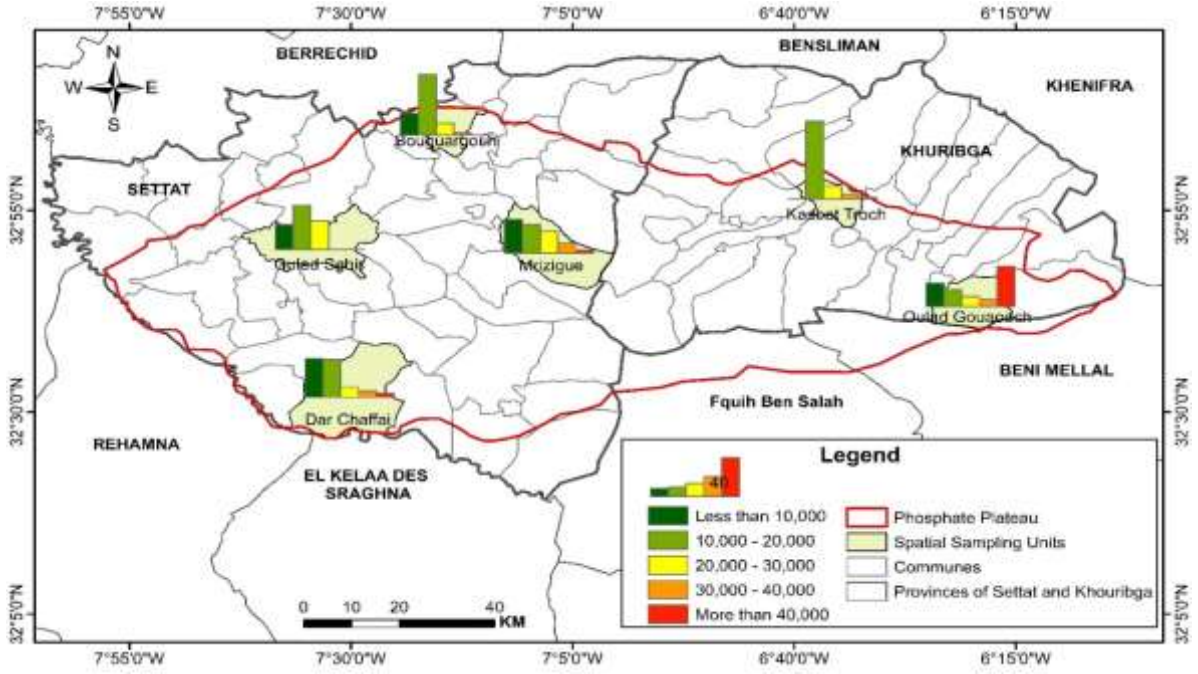

Figure 8: Distribution of Individual Income from Agricultural Activity in the Spatial Units of the Phosphate Plateau.

This income is insufficient to cover household expenses, even during good harvest seasons, according to residents, due to the high costs associated with the various stages of production. This production remains largely geared towards self-sufficiency, representing approximately 63%, while production based on marketing and self-sufficiency constitutes 37%, given the region's semi-arid characteristics and limited marketable production capacity.

The rise in agricultural product prices is exacerbating the economic situation of the population The prices of agricultural products are determined by the generosity of the climate and the

productivity of the land, and are characterized by instability according to periods of scarcity and excess of rainfall. It decreased to 2.90 (dirhams/kg) for durum wheat, 2.50 (dirhams/kg) for soft wheat, 1.66 (dirhams/kg) for barley, and 2.85 (dirhams/kg) for corn, during the years 1996, 1997, and 1998, and then in 2003 and 2009 (Fig. 9).

While prices rose to over 3 dirhams per kilogram for various products during several years, such as 1992, 1993, and 1995 (during severe droughts), and again during the periods of 1999-2002 and 2004-2008, this increase continued in recent seasons with successive droughts. The price of staple grains exceeded 5 dirhams per kilogram, and legumes 10 dirhams. As for animal feed, such as bran (flour residue), its price exceeded 3 dirhams per kilogram, and the price of straw (agricultural crop residues) used as fodder and hay for livestock ranged between 40 and 60 dirhams per unit in all the studied areas (Field Research, 2021).

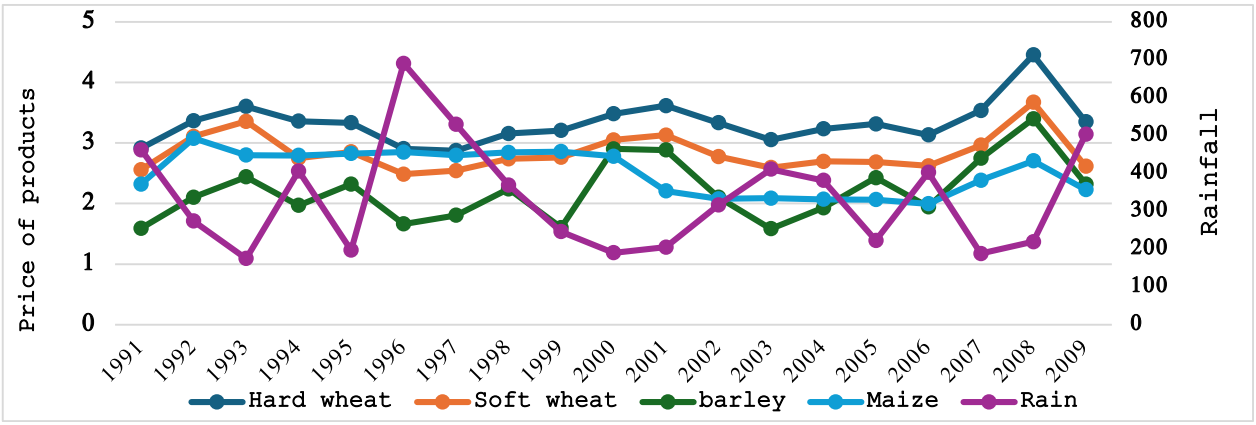

Figure 9: Evolution of the Price of Main Products and Their Relationship to the Amount of Precipitation During the Period Extending Between 1991 and 2009 in Dirhams/kg.

This increase in the price of products limits the purchasing power of the population of the phosphate plateau and of the country as a whole, both in terms of food consumption and in terms of managing the upcoming agricultural season.

Weak cooperative activity and state interventions for agricultural sector development

Cooperatives involved in milk collection and offering various services constitute 71% of the total in the Settat region (Upper Chaouia) and 66% in the Khouribga region (Ouardigha Plateaus), outnumbering other cooperatives focused on agricultural reform and livestock breeding (Table). The distribution of these cooperatives remains weak in rural areas, not exceeding 23%, concentrated in the communes of Oulad Gouaouch, Oulad Sghir, and Kasbat Troch, while being absent in the other studied communes.

Table 3: Distribution of Cooperatives in the Areas of Settat and Khouribga in 2014.

Cooperative	Settat Province	Khouribga Province
Agrarian reform	21	4
Agricultural equipment	1	-
Livestock	3	7
Milk collection	111	98
Beekeeping	1	4
Supply	2	-
Exploitation of agricultural lands	3	-
Watering	1	-
Grain production, Vegetables and Oils	3	-
Multiple services	9	-
Other cooperatives	-	34

Approximately 29% of the population across all territorial units expressed the importance of cooperative Tableau 3 providing economic conditions through milk sales and access to distributed fruit trees, certain types of seeds, animal feed, and livestock medicines.

Furthermore, farmers' participation in projects programmed under the Green Morocco Plan is very

limited, not exceeding 3% of all territorial units surveyed. This percentage rises to 11% in the commune of Oulad Sghir and 7% in the commune of Dar Chafi, but falls below 2% in the remaining territorial units. This is compounded by weak participation in professional organizations and a lack of training and capacity building for farmers.

Adopting agricultural diversification and planting fruit trees for agricultural development In the phosphate plateau, 42% of farmers in the area adopt agricultural diversification as an individual initiative, focusing on supplementary crops to increase their income. The highest percentage is recorded in the commune of Oulad Sghir at approximately 98%, followed by Boukerkouh at 76%, and then Mrizigue at 45%. The lowest percentage, less than 30%, is recorded in the remaining rural units. Meanwhile, fruit tree planting constitutes 58% of all surveyed rural units. It is particularly prevalent in the communes of Mrizigue and Bouguargouh (approximately 80%), followed by the communes of Dar Chaffai and Oulad Gouaouch (approximately 70%). In the remaining communes, it is less common (less than 20%) due to water scarcity (Fig10).

Olive cultivation ranks first at 47%, followed by figs at 13%, while oranges and plums occupy the last place at no more than 5%.

Farmers have increasingly adopted fruit tree planting, especially after 2000, due to their awareness of the added financial benefits compared to grain cultivation.

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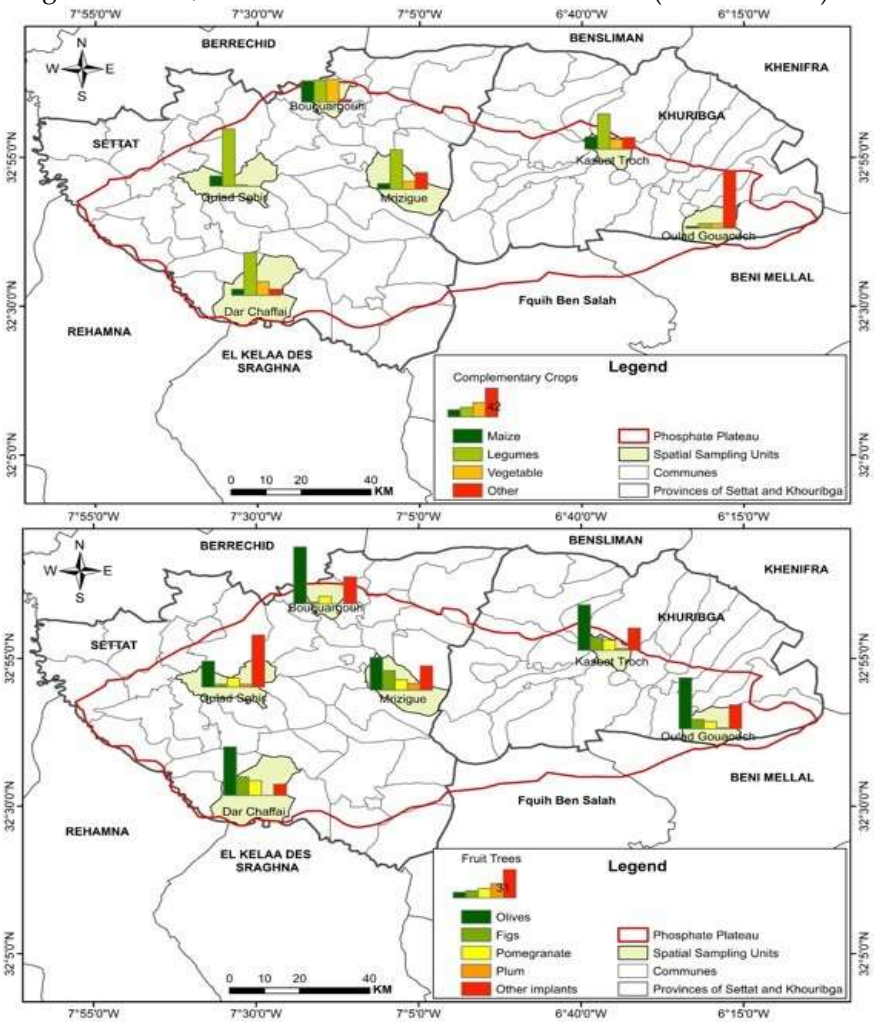

Figure 10: Distribution of Agricultural Diversification in the Phosphate Plateau.

Olive cultivation ranks first at 47%, followed by figs at 13%, while oranges and plums occupy the last place at no more than 5%.

Farmers have increasingly adopted fruit tree planting, especially after 2000, due to their awareness of the added financial benefits compared to grain cultivation.

Degree and reasons of satisfaction with agricultural activity in the phosphate plateau

Residents' satisfaction with agriculture and livestock farming varies across the phosphate plateau. Most farmers expressed dissatisfaction with agricultural activities, with dissatisfaction rates ranging from 95% in the municipality of Kasbat Troch (85% dissatisfied and 10% very dissatisfied) to 60% in the municipality of Dar Chiffai. Similarly, dissatisfaction with livestock farming ranged from 92% in Kasbat Troch to approximately 78% in the municipality of Ouled Gouach (Fig. 11).

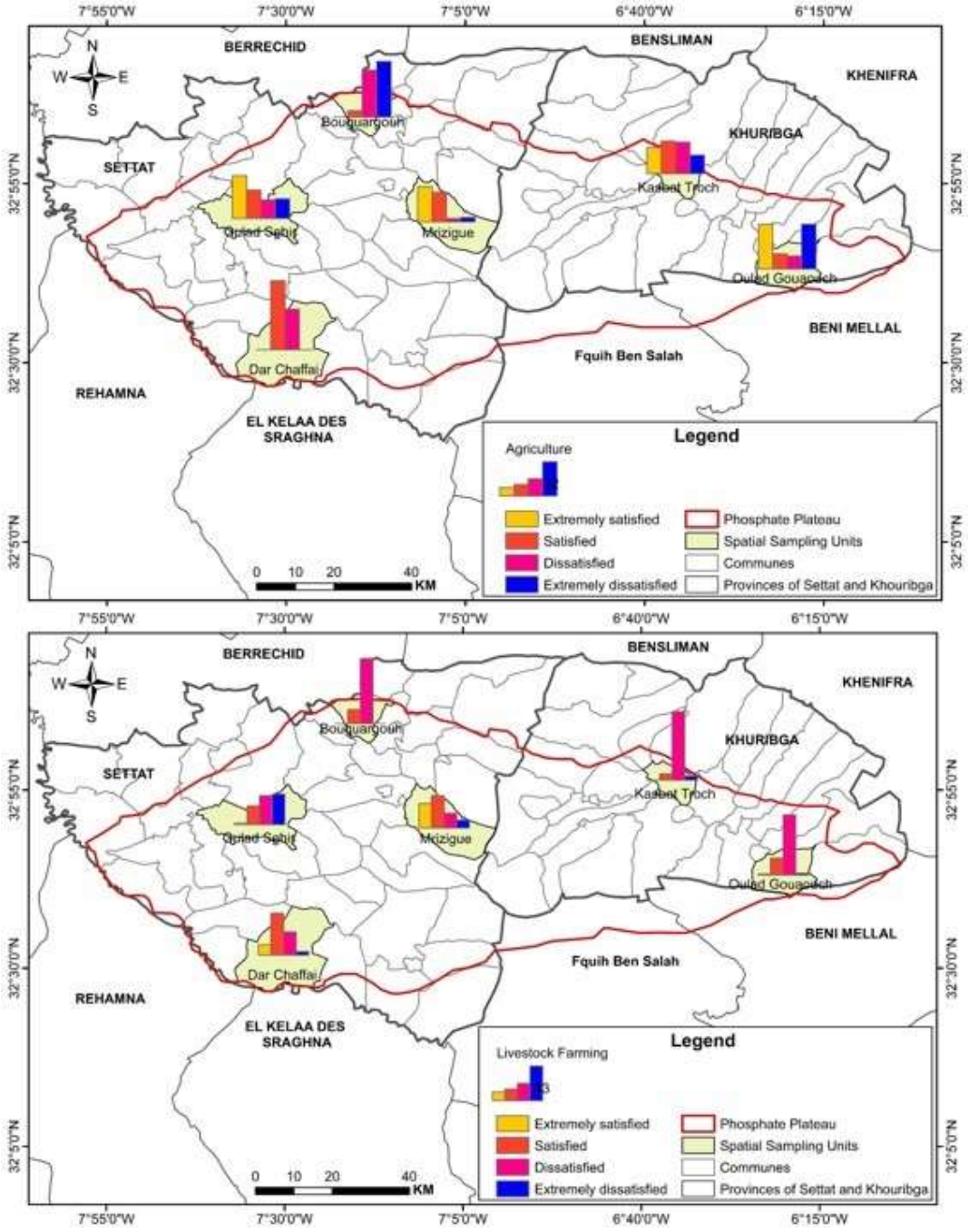

Figure 11: Distribution of Satisfaction Levels Regarding Agricultural Activity.

The farmers' dissatisfaction with their agricultural activities stems from several reasons, primarily the

recurring droughts, a 28% decrease in production, the lack of government support, and the approximately 27% increase in grain costs (Fig. 12). The farmers' dissatisfaction with their agricultural activities stems from several reasons, primarily the recurring droughts, a 28% decrease in production, the lack of government support, and the approximately 27% increase in grain costs (Fig. 12).

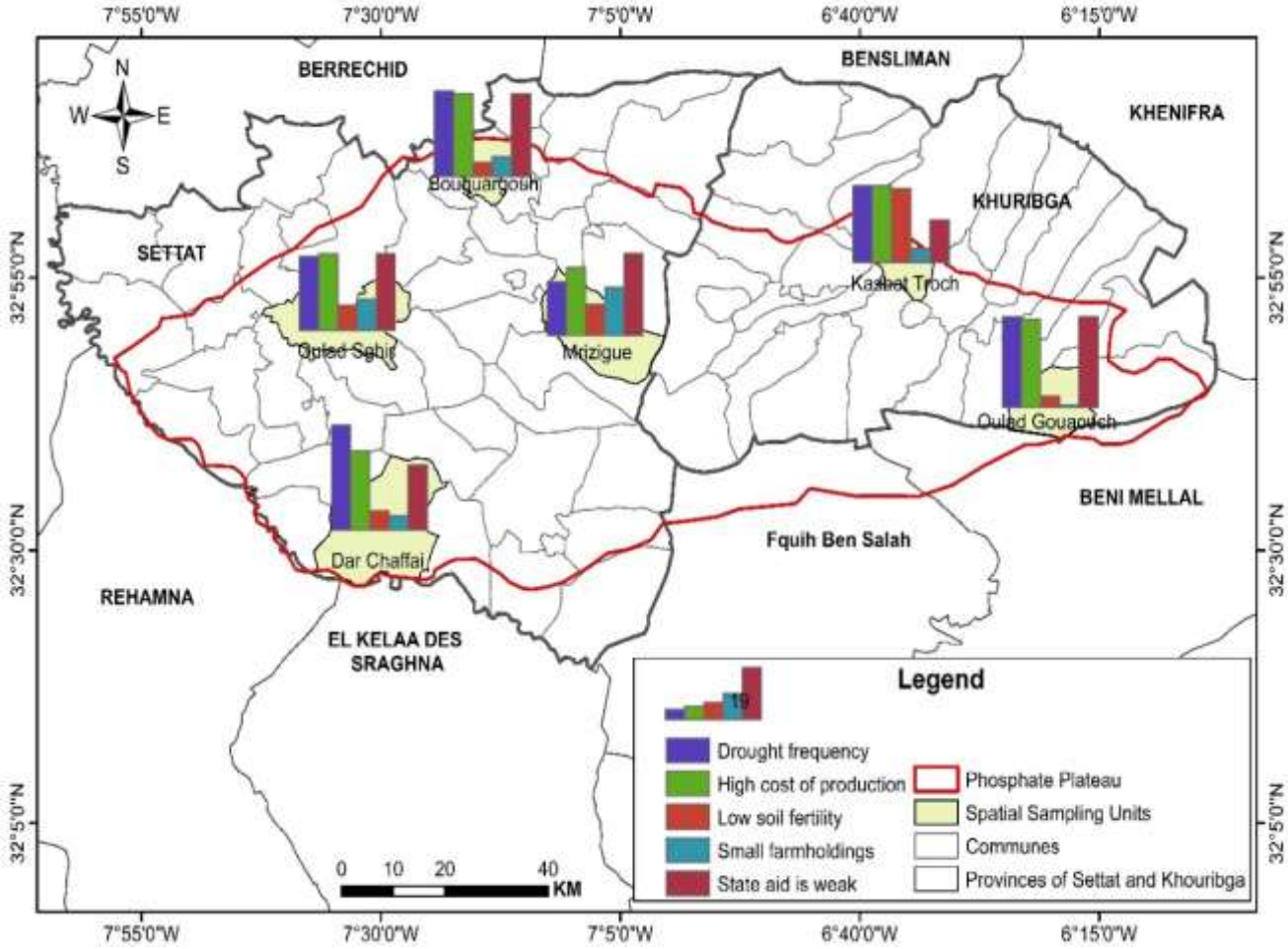

Figure 12: Reasons for Dissatisfaction with Agricultural Activity in the Phosphate Plateau.

Most farmers confirmed that the main reason for their dissatisfaction with livestock farming is the high costs resulting from recurring droughts and the low economic viability. This pushes them to resort to various measures, including selling part of their herd to buy feed (76%), then selling the entire herd (11%), while 13% of the surveyed farMs chooses to buy feed while keeping their livestock**.**

Some farmers resorted to selling their land, or part of it, during periods of drought, which affect 16% of the phosphate plateau. Others migrated, with the head of the household or their children migrating to provide financial support for agricultural activities. This migration accounts for approximately 33% of all migrant workers across the region. This situation is a result of the lack of job opportunities in the area, particularly among young people, a crucial Human resources.

Engaging in non-agricultural activities to develop household income in the phosphate plateau Rural residents are turning to non-agricultural activities to combat poverty and improve their living standards. The highest rate was recorded in the municipality of Boukerkouh at approximately 52.5%, followed by the municipality of Amrizik at approximately 51.7%, and then the municipality of Dar Chifai at 37.3%, while the crucial issue for humans was recorded in the municipality of Ouled Sghir at approximately 27%. Trade ranks first at 40%, followed by rental services at 26%, while other activities come in last at 16%(Fig.13).

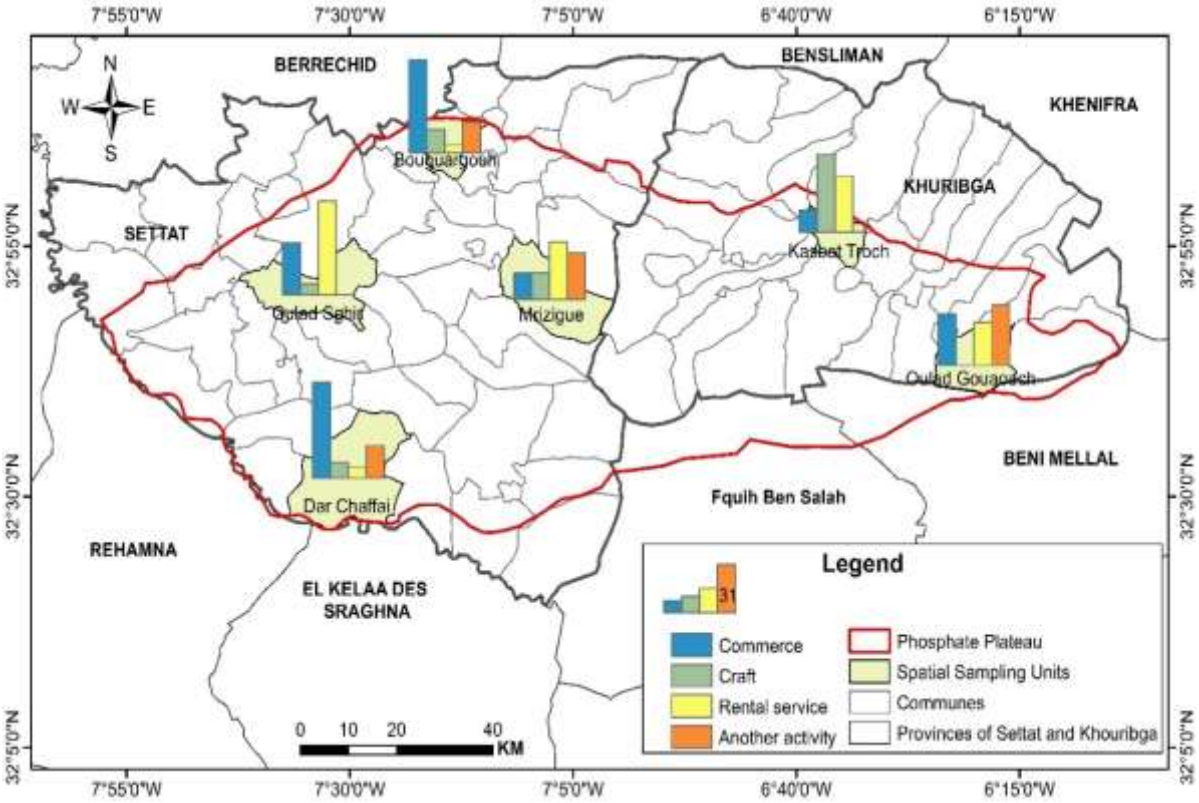

Figure 13: Distribution of Non-Agricultural Activities Practiced in the Phosphate Plateau.

3.3.2. Adaptation Measures and Agricultural Development in the Countryside of the Phosphate Plateau

Numerous negotiations and international agreements have emphasized the need to take action against climate change and adapt to it. One such measure is the imperative to re-evaluate conventional methods of economic development that harm the environment. Instead, it is crucial to devise medium and long-term economic plans and programs that gradually phase out these methods and replace them with clean, sustainable alternatives based on the principles of the green economy and renewable energies. This includes all economic sectors.

Morocco, a signatory to the Kyoto Agreement, implemented the "National Plan to Combat Climate Warming in 2009. This plan incorporates sectorial measures in various fields to foster the adaptation of social, economic, and environmental systems to climate change. Notably, the plan prioritizes the forestry and agriculture sector, given its status as a primary economic activity in the country (Secretary of the State in charge of Water and Environment, 2009).

As a result, the emphasis on agricultural development has overshadowed rural development, particularly in the fallow regions. These areas, which comprise a significant portion of the national territory at 83% of the arable land and are home to over 70% of the rural population, continue to be impoverished and serve as a catalyst for migration. In 1995, after years of being overlooked, public authorities established a framework for a unique strategy aimed at uplifting underdeveloped, unirrigated agricultural lands and introduced Law No. 33-94. This initiative sought to empower marginalized areas by bolstering productivity, improving income levels, preserving natural resources, and creating employment opportunities, all with the ultimate goal of bettering living conditions and combatting poverty.

The Ministry of Agriculture and Rural Development undertook over 200 projects in diverse agricultural regions, each with unique environmental characteristics. This was in line with the Economic and Social Development Plan 2000-2004, which aimed to complete 70 additional projects across the country. Subsequently, the Horizon 2020 strategy was launched to enhance the infrastructure of medium-sized centres, offering essential services to industrial and manufacturing industries, while bridging the gap between urban and rural areas.

In 2009, the Green Morocco Plan was successfully implemented to address the challenges posed by climate change. The plan included various projects such as optimizing and securing grain production, modernizing crop and fruit tree cultivation, and enhancing agricultural preparedness. It also focused on developing the red meat industry and promoting professional organizations. Building on the successes of this initiative, a new strategy was launched, known as the "Green Generation 2020-2030".

The objective of these initiatives is to enhance the efficiency of grain and fruit tree cultivation, with a particular focus on olives, while also improving pastures and optimizing the meat supply chain. Furthermore, the initiatives look to foster job growth, enhance the earnings of farmers, and boost overall value. To preserve the environment, these projects aim at mitigating erosion factors and promoting the legalization of irrigation practices. By utilizing a drip irrigation approach, the initiatives can help preserve the waterbed.

4. DISCUSSION

It seems that the rural population in the Phosphate Plateau relies heavily on mullet agriculture, with a particular emphasis on cultivating cereals and barley. Livestock rearing also plays a significant role, with sheep being the primary focus, followed by cows and goats. This is due in part to the availability of expansive pastoral lands that have facilitated the growth of this industry.

The weak proportion of agricultural land, the multiplicity of exploitations, and the dominance of smallholdings hinder the optimal exploitation of land and good production.

Agriculture is particularly susceptible to the effects of climate change, particularly concerning rainfall. The dry seasons can cause a decline in production and cultivated areas due to inconsistent and insufficient precipitation. The scarcity of natural resources such as water and soil further complicates matters, necessitating the adoption of supplementary irrigation during certain periods of crop growth. Diversification of agricultural production can also prove beneficial in this context.

Marketable agricultural products benefit the farmer economically and improve his level of income, as this income remains limited from agricultural activity and unstable, dependent on the generosity of the climate and its temporal precipitation for the sake of a return that secures his livelihood.

In the face of these challenges caused by climate change, it has become necessary to integrate climate change into public policies and to implement international conventions to mitigate and adapt to it, especially in sensitive sectors such as water resources and agriculture, as they are the economic and social engine and the basis of development.

5. CONCLUSION

Rural areas face several economic and social challenges, including a lack of infrastructure, facilities, industrial units, and investments, and the fragility of the agricultural sector. The impact of climate change and the prevalence of drought seasons have a severe effect on the productivity of farmers and their ability to sustain their livelihoods. As a result, the economic and social conditions of farmers are further compromised, leading to a decline in their income. This, in turn, leaves them struggling to meet the basic needs of their families, especially with the rise in prices of food and agricultural products. Their reliance on agricultural and fodder activities exacerbates this situation. Families in non-agricultural communities often seek alternative economic opportunities, such as immigration, to improve their financial situation. Unfortunately, many face the challenge of limited education due to low household income. This is compounded by the lack of stable local economic activity, which makes it difficult to generate additional income.

Morocco has implemented a range of measures to tackle climate change, including initiatives like the Morocco Plan, which aims to combat warming, and the Green Generation project. These efforts have had a positive impact on the local agricultural sector, but there is still work to be done to ensure that all communities within the Phosphate Plateau can benefit from them. Ultimately, the goal is to promote sustainable economic development while also mitigating and adapting to the effects of climate change.

REFERENCES

Atillah, R., Abdellaoui, & Boufdili. (1996). Interactions océan–atmosphère et dynamique climatique globale. *Géo-Observateur*, (6), 22.

Balaghi, R., Jlibene, M., Benaouda, H., Kamil, H., & Debbarh, Y. (2011). Projet d'intégration du changement climatique dans la mise en œuvre du Plan Maroc Vert (PICCPMV). INRA et Agence pour le Développement Agricole, Maroc. 98 pages.

Debrach, J., & Bidault, G. (1956). Précipitations atmosphériques au Maroc 1925–1949 : fréquences et intensités des précipitations. *Annal. Servi. Physique. Global. et Météore.*, Institut Scientifique Chérifien, 16, 77–116.

Fadlallah, A. J. (1983). Recent temporal and spatial changes in grain production in Morocco. *Moroccan Geography Journal*, 7 (New Series), 36.

Ferreira, F. R., & Pereira, L. S. (1982). L'estimation de référence (ETo), étude comparative de plusieurs formules climatiques. *Hommes Terres et Eaux*, (12), 33. Rabat.

Fezzaz, M. (1986). Modélisation agroclimatique. Étude des risques des contraintes imposées par la sécheresse aux céréales d'automne : cas de trois régions au Maroc. Mémoire de troisième cycle, IAV Hassan II. p. 4.

Global Meteorological Organisation. (2014). The global climate in outer space and indentations.

Karrouk, M. (2012). Changes in climate and impacts in Morocco: Complexity of new climates and detection of the water cycle. In *Environment and Climate Change in Morocco: Diagnostics and Perspectives*.

Snoussi, M., Niazi, S., Khouakhi, A., & Raji, O. (2010). A GIS-based vulnerability and impact assessment: The case of the Moroccan coast. In Maanan, M., & Robin, M. (Eds.), *Geomatic solutions for coastal environments*. Nova Science Publishers. https://www.novapublishers.com/catalog/product_info.php?products_id=12464

Scientific Facts on Water. (2008). State of the resource. GreenFacts Website.

Global Meteorological Organisation. (1992). Vocabulaire météorologique international (Note technique No. 182). Genève.

Khatrani, H., & Sghir, S. (2026). The importance of the geographical matrix in identifying spatial sampling units in studying the effects of climate change on water resources and agricultural production in semi-arid areas of Morocco and ways of adaptation: The case of the phosphate plateau. Publications of the Democratic Arabic Center GmbH, Berlin, Germany.

Khatrani, H., & Sghir, S. (2021). L'effet des changements climatiques sur la production agricole dans les zones semi-arides au Maroc et les possibilités d'adaptation : le cas de la province de Settat. *Actes du 34e colloque annuel d'A.I.C.*, Université Hassan II de Casablanca, F.L.S.H. Mohammedia, Maroc.

Sghir, S. (2002). L'aménagement hydro-agricole en Doukkala : impacts sur l'organisation socio-économique et spatiale (Doctoral dissertation). Université de Metz, p. 21.

Turc, L. (1961). Évaluation des besoins en eau d'irrigation : évapotranspiration potentielle, formule climatique simplifiée et mise à jour. *Annales Agronomiques*, 12(1), 13–51. Paris.

McKee, T. B., Doesken, N. J., & Kleist, J. (1993). The relationship of drought frequency and duration to time scale. In *Proceedings of the Eighth Conference on Applied Climatology* (pp. 179–184). American Meteorological Society.

Sources of Official Departments and Agencies

Regional Directorate of Agriculture, Khouribga and Settat Provinces. (n.d.). Official reports.

Agricultural Advisory Offices, Khouribga and Settat Provinces. (n.d.).

Meteorological Station, Settat and Khouribga Provinces. (n.d.).

Social Development Agency, Settat Province. (n.d.).