

Impacts of climate change on migrations in the Mediterranean environment: Case of the Prerif mountains (Morocco)



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Abstract

Due to its geographical position within the Mediterranean basin, Morocco is one of the countries most vulnerable to climate change. In the Prérif mountains, climatic and, consequently, hydrological droughts during recent decades had dramatic consequences not only on agricultural yields but also on the physical and human environment. The water shortage and the failure of the agropastoral system have greatly accelerated unprecedented migratory movements of rural population towards neighboring towns. Our household surveys, in some municipalities, show that a rural decline is already affecting certain sectors considered repellent.

This contribution aims to analyze decreasing trends in rainfall and characterize the severity of droughts and their consequences in the region. The approach adopted is

based on an analysis of rainfall data from two stations in the region (search for trends and cycles) as well as on the use of the Standardized Precipitation Index (SPI). Likewise, household surveys were carried out in different municipalities with the aim of assessing the impacts of recurrent droughts on agricultural production and the stability of rural populations.

Keywords: Climate change, droughts, rural migration, Prérif, Morocco

* Introduction

Climate change have a significant impact on the availability of water resources, leading to a disruption of the natural seasonal regimes of watercourses and a reduction in the storage capacity of groundwater and dam reservoirs. The recurrent droughts in Morocco since the 1980s had negative effects on the stability of rural populations. They caused a flagrant shortage of water

resources in most rural areas of the country. This had negative repercussions on the agro-pastoral system, and on the entire physical and human environment. This exceptional drought led to the aridification of the environment and inevitably to an economic and social crisis, resulting in rural abandonment and intense migratory movements. As a result of the difficult socio-economic situation, farmers were forced to look for solutions outside their own environment (5. Gauché, E. 2005 – 13. Tribak. 2019). Large numbers of people are leaving repulsive mountain areas in the hope of finding the means to live more comfortably elsewhere (13. Tribak. 2019). On a national scale, between 1982 and 1994, the urban population grew by almost 5 million people, an annual increase of almost 390,000, compared with just over 265,000 between 1971 and 1982 (6. HCP. 2005). As for migratory movements, which account for almost 40% of the total, it is estimated that 1.9 million rural dwellers have left the countryside for the city, representing a net annual influx of around 156,000 rural dwellers (6. HCP. 2005). Between 1982 and 1994, the annual growth rate was 3.6%. The percentage of urban dwellers now exceeds that of rural dwellers: 51% in

1994, compared with 43% in 1982 and 35% in 1971 (8. Joumady. K., 1999). In the Prerif mountains, water scarcity is seen as a fundamental parameter of the environmental and socio-economic crisis that characterized the region during this period. The hydrological deficit resulted in a flagrant lack of water and an alarming reduction in agricultural and pastoral production, with their direct consequences resulting in massive migratory movements towards the surrounding towns. The aim of this paper is to analyze the impact of the recurrent exceptional droughts that have affected this zone since the 1980s and to assess their consequences for the stability of rural populations.

This paper addresses a significant conceptual gap in the current literature by examining the specific impacts of climate change-induced droughts on rural populations and their subsequent migration patterns. The research not only investigates the environmental consequences but also links these impacts to broader socio-economic issues, contributing to the ongoing discussions about the resilience and sustainability of rural communities facing such pressures.

The aim of this paper is to analyze the impact of the recurrent

exceptional droughts that have affected this zone since the 1980s and to assess their consequences for the stability of rural populations. This study also fits within the broader context of sustainability and resilience, offering new insights into how environmental change can drive migration and affect both rural and urban areas.

* Study area

The Prerif constitutes the southern part of the outer furrow of the Rif Mountain range. The geomorphological evolution of this area during the Quaternary is characterized by the incision and deepening of the valleys in the soft formations. This has resulted in very significant differences in level between the valley bottoms and the hilltops. The lithology is highly complex, due to the thrusting of Mesorifan nappes, represented by a predominance of soft materials (1.Avenard, 1962). These nappes are made up of marls and clays from the Cretaceous, Eocene and Miocene, sometimes associated with Triassic gypsum and salt deposits in the form of diapirs. In terms of climate, the study area is characterized by a continental climate with hot, dry summers and cold, relatively wet winters. Average annual rainfall varies considerably, with 495 mm

recorded in Ain Aicha station over the reference period (1981-2018), 600 mm in M'jaara (1956-2012) and 594 mm in Taza (1970-2017). Rainfall is marked by significant inter- and intra-annual variability, which has a major impact on crop yields and rangeland productivity. Demographically, the Prerif is a major population home, almost entirely rural, which still records high human densities despite the migratory movements that have been increasing in recent decades.

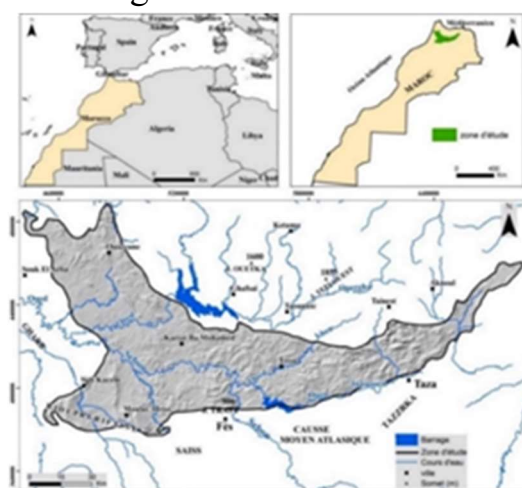


Figure 1: Geographical location of the Prerifan area

* Méthodology

The approach is based on the use of meteorological data relating to series of annual parameters from the Ain Aicha station (1981 - 2018) and the Taza station (1970- 2018), located in the preriferan zone. Other climatic data were taken from bibliographic references from previous studies (13.Tribak, 2019 and 2020; 9. Nejari, 2005; 2. Azagouagh, 2021).

The purpose of using the data collected at the various stations is to examine rainfall patterns, highlight their evolution in relation to a fairly clear trend towards drought since the 1980s, and above all to assess in greater detail the periods of extreme drought, which are key factors in the instability of rural populations. Similarly, we also applied the SPI method for processing rainfall data, with the aim of defining the phases of drought that have a serious impact on the region. The archives and administrative reports of the Haut-commissariat au plan (HCP) were useful in supporting our fieldwork findings, particularly with regard to changes in agricultural production in the Prerif. Field surveys were the main source of information for identifying the impact of recurrent droughts on the agro-pastoral system and the mobility of populations. Surveys were the main source of information for identifying the impact of recurrent droughts on agropastoral systems and population mobility. To carry out this step, we conducted surveys in 3 Douars located in the Prérif region (Douar Boujemaa, Douar Bouhcina and Douar Bouchala in the rural communes of Ain Aicha, Oulad Daoued and Oued Jemaa) with a total number of 60 households. In

addition, field surveys were carried out on changes in the number of sheep per household. The same applies to changes in average annual olive production in tonnes per household from a wet to a dry year during the period in question.

*** Résultats and discussion**

In the Prerif mountains, climatic and consequently hydrological droughts over the last few decades have resulted in the aridification of these environments, as well as a severe shortage of water resources at the heart of the wet season. Annual data from the Ain Aicha station (1981-2018) and the Taza station (1971-2018) show that rainfall is highly irregular (Figures 1 and 2). The results show a significant drop in rainfall over the period 1980-1995. Wet periods are often interspersed with dry years, which can sometimes be very severe (as was the case in 1993, 1995 and 2007). The majority of annual values for this period are below average, with the exception of a few years with values in excess of 500 mm. 1995 was the most severe year, with some of the lowest annual rainfall recorded, at 241 mm in Taza and 285 mm in Ain Aicha. The results of the analysis of annual rainfall show that the most remarkable droughts in terms of intensity and duration occurred

during the period 1980-1995. These droughts reached their peak in 1983, 1993 and 1995, qualified as extremely severe.

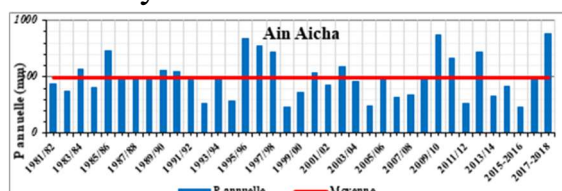


Figure N°2: Annual rainfall (Ain Aicha station 1981-2018. Source: AHBS)

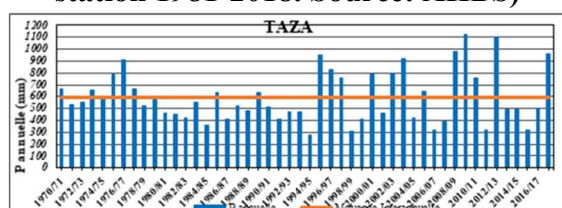


Figure 3: Annual rainfall (Taza station 1971-2018. Source: AHBS)

Similarly, a study of the Standardized Precipitation Index (SPI) allowed us to characterize the severity of these droughts. Figures 4 and 5 show the high variability of the SPI values, expressed by a lack of homogeneity between years, with significant fluctuations between positive and negative values and a clear trend towards dry spells. From 1971 to 2010, five dry sequences were observed at the Taza station (the years: 1975, 1981 - 1985, 1987 - 1995, 1998 - 2001 and 2005 - 2007). The year 1994-1995 remains the driest, with respectively SPI values of -0.93 and -1.12 (Figs. 4 and 5).

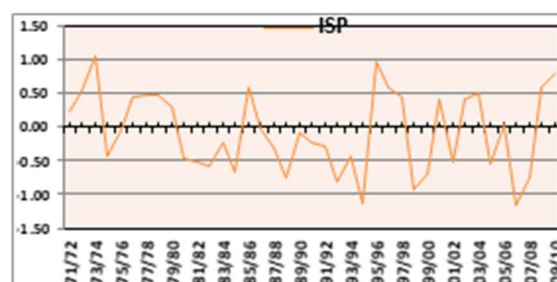


Figure 4: SPI values (Taza station 1971 - 2011)

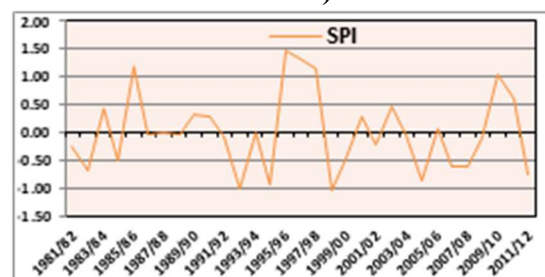


Figure 5: SPI values (Ain Aicha station 1971 - 2011)

In terms of analyzing dry periods, which have a very negative impact on the prerifan environment, it is quite clear that recent droughts (1980-95 and 2000-2008) are characterized by an intensity that is essentially reflected in the recurrent nature of very deficit years (13. Tribak et al., 2019- ;9. Nejari. 2005; 3. El-Amrani, H. 2018, 14. Tribak, A. 2020).). Similarly, the absolute droughts that occurred between crop years, which were fairly frequent at the time, reflect a disruption in seasonal rhythms. These severe droughts had serious consequences for the environment, reflected in a flagrant lack of water at the heart of the wet season and an importante reduction in agricultural and pastoral production. This depletion has led to a total drying up

of a large number of springs and a flagrant reduction in river flows. Hydrological data from prerifan stations highlight the extent of the flow deficiencies during this period of drought. At the Bab Merzouka station, located upstream of the Oued Inaouene, flows over the period 1980-1984 remained below 3 m³/s. The water shortage had also a major impact on agricultural production in terms of quantity. Agricultural statistics from the HCP (2016) show the sharp fall in cereal production in the rural communes of the Prerifan area. For example, in 1994/95, cereal production in the Taounate circle fell by 578.6 thousand quintals; by contrast, during the wet year (2005/06), production was estimated at 5833 thousand quintals (Figure 6). In addition, our field surveys revealed a drop in the number of sheep per household, from 16 in a wet year to just 6 in a dry year. The same is true of the change in average annual olive production, which shows the same trend as for other crops: 0.72 ton per household in a wet year compared with 0.31 ton per household in a dry year during the period in question (Azagouagh, 2021).

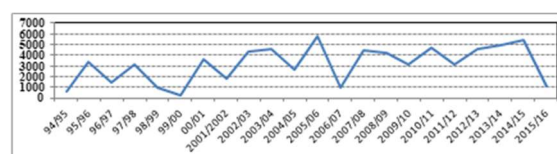


Figure No. 6: Evolution of cereal production in thousands of quintals (Taounate, 1994-2016)

Source: personal work.

The exceptional drought conditions, referred above, led to an economic and social crisis, resulting in intense migratory movements from the early 1980s onwards. Faced with very difficult situations, due to the failures of the agro-pastoral system and the precariousness of living conditions, Rural populations leave repulsive mountain areas in the hope of finding the means to live more comfortably in urban areas (5. Gauché, E. 2005 – 13. Tribak, A et al 2019). Data on population trends between 1982 and 2014 show effectively that a phase of rural depopulation is already affecting a large number of rural municipalities, which are becoming increasingly repulsive (10. ONDH, 2010). For example, the annual growth rate was generally low or even negative for some of the region's communes over the period 1982-2014; this was the case for the communes of Mkansa, Ouled Chrif, Taifa, Ain Legdah, Outabouabane, Ras el Oued and Beni Frassene (Figure 7).

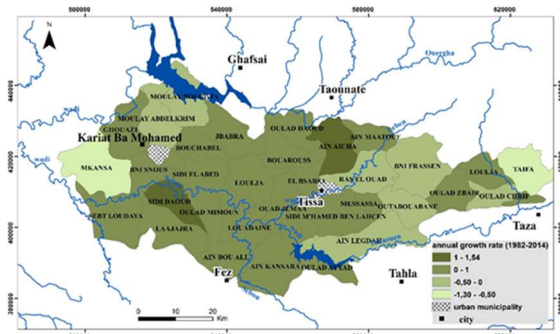
Table 1: Rate of increase in the population of rural communes (Taounate 1982 – 2014)

Communes	Populati on 1982	Populati on 1994	Populati on 2004	Populati on 2014	TA A % 198 2-94	TA A % 199 4-04	TA A % 200 4-14
BOUHOU DA	١٨٨٤٢	23257	26124	26236	١,١٧	1,17	0,04
ZRIZER	٦٩٨٤	7666	7934	7922	٠,٧٨	0,34	- 0,02
RGHIUOA	٦١٥٠	5528	4802	4218	- 0,88	- 1,40	- 1,29

Source: Directorate of Statistics, Rabat, 1982, 1994, 2014).

By way of comparison, in some communes of the central Rif, the rates of change remain low or even negative (4. El-Ommal, M. 2021). Between 1982 and 1994, Some communes located downstream of the Sra basin have experienced negative population growth due to the negative impact of drought periods and the deterioration in the quality of life of farmers, such as the commune of Rghouia, where the growth rate was -0.88%. Similarly, this municipality also had negative rates between 1994 and 2004 of around -1.4 and between 2004 and 2014 (-1.29%). The same applies to the municipality of Zrizer, which recorded a negative rate between 2004 and 2014 of around -0.02% (Table 1) (4. El-Ommal, M 2021) . Also in Taounate province, several rural communes recorded negative annual growth rates between 1994 and 2004: Aïn Guedah (-0.2%), and Ras el Ouad (-0.2%). Over the same period, 30% of the douars in the Hyayna country in the pre-serf zone

also recorded negative rates, including 5.4% with rates below 5%, and 10.8% with rates between -5% and -2%. (10. ONDH., 2010). Our personal survey of migrants living on the outlying areas of the Fez city shows that the majority of these residents come from the Prérif region, in particular from the communes and douars of Taounate and Taza. The survey reveals that 43% of the population settled there during the 1980-1990 period, which corresponds to the recurrent droughts that accelerated migratory movements towards the city of Fès. The survey also revealed that a large proportion of migrants came from various regions of the Prérif, including Taza (14%), Taounate (24%), Oulad Jamee (16%), Hyayna (21%), Chraga (8%). and others (17%). Similarly, our survey of the douars in the Prérif region confirms this finding. 48% of those questioned firmly believe that recurrent droughts, and consequently the lack of water and the failure of the agro-pastoral system, remain the main cause of the rural exodus.



of its urban fabric; it currently covers an area of around 11,000 ha. According to the 1991 SDAU, the surface area of Fez increased from 3,878 ha in 1960 to 6,550 ha in the 1980s; a period that saw the emergence and expansion of non-regulated outlying districts. It experienced the strongest demographic growth from the 1980s onwards. Its population rose from 584,000 in 1982 to 772,000 in 1994 and 1,150,000 in 2014, with an annual growth rate of 2.97% in 1982 and 3.93% in 1994.

The relationship between climate change, drought, and migration has been widely studied, highlighting the socio-environmental dynamics resulting from environmental pressures. Research by (5.Gauché, E. 2005) and (13.Tribak. A. 2019) reveals the recurrent droughts in Morocco since the 1980s, disrupting hydrological cycles, depleting groundwater reserves, and reducing dam storage capacities. These droughts severely impacted agro-pastoral systems, leading to declining agricultural productivity and economic stagnation. Consequently, rural communities, particularly in the Prérif mountains, experienced significant outmigration driven by environmental and socio-economic

instability. Studies also show that water scarcity in the Prérif region triggered massive migration flows to urban areas, with rural-urban migration accounting for a substantial share of urban growth between 1982 and 1994 (6.HCP. 2005).

Theoretically, this phenomenon aligns with frameworks of environmental migration and resilience, where migration emerges as an adaptive response to declining livelihoods. However, a research gap persists in exploring the long-term implications of such migration on rural and urban systems, as well as strategies to enhance sustainability and resilience. This study contributes to this discourse by analyzing the drivers of migration in the Prérif region and offering recommendations for strengthening local resilience against climate-induced challenges. By integrating these findings into broader debates on sustainability and the Sustainable Development Goals (SDGs), this research enriches ongoing discussions on climate adaptation and rural development in vulnerable regions.

*** Conclusion**

Recent climatic changes, characterized by a high recurrence of dry periods, had a significant impact on the availability of water resources in the mountains of the Moroccan

Prerif. This had negative repercussions on the agro-pastoral system and on the entire physical and human environment. The flagrant lack of water resources was the cause of social unrest, resulting in massive migratory movements to neighboring towns from the 1980s onwards. The global demographic haemorrhage characterizing certain mountain environments and the intensity of migratory movements are a response to the failure of the agro-pastoral system under the effect of recurrent droughts, in a context of global economic crisis. the intensive mobility of rural populations testifies to the importance of water as a limiting factor in the relationship between people and their environment in the deprived areas of the prerif. The shortage of water has led surely to an unravelling of the links between the population and their environment. In this context, the city of Fez, like other large cities, is going through a period of profound change, characterized by rapid and irrational expansion towards the outlying areas that provide refuge and large reception capacity for migrants from poor social categories. This has led to a great discordance between districts in terms of infrastructure and represents a major challenge for urban planning and management.

The sustainable management of water resources, a determining factor in the stability of rural populations, remains a national priority that all local development policies must take into account to reduce the consequences of any recurrent drought.

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