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Assessment of the impacts of the meteorological drought on the Livestock Sector in the Province of Taza, Morocco

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Abstract

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Drought is having a detrimental impact on crops and livestock around the world, but less attention has been paid to outdoor livestock, particularly in North African countries. More specifically, this study aims to assess meteorological drought according to the Standardized Precipitation Index (SPI) and measure its impact on livestock productivity in the province of Taza (Morocco). After assessing meteorological drought, the study takes into account three opposite climatic periods for establishing the link between meteorological drought and fodder and straw bale prices on the one hand and, on the other hand, the level of reproduction of the livestock based on a field survey. The results showed that the province of Taza has known six drought periods that are characterized by mild to extreme severity between 1931 and 2019. In addition, straw bale prices, fodder prices and mortality increased. In contrast, reduced fecundity, size and prices of livestock in reaction to the meteorological drought. This situation prompted herders to sell their livestock in order to reduce their expenses, leading to a collapse in livestock prices on local markets.

Keywords: meteorological drought; livestock; Standardized Precipitation Index; Taza

Introduction

Unlike most Third World countries that have opted for an industrialization suitable for their development, Morocco has, since the early years of its independence, placed agriculture at the heart of its development policy (Belmahi, Hanchane, Mahjoub, et al. 2023; FAO 2014; Qarouach 1987). For this, agriculture is a fundamental pillar for the Moroccan economy, as it contributes from 11 to 14% to gross domestic product with an average of 12.5% over the period 2000-2020, compared to 20% between 1965 and 1980 (World Bank, 2021). It is one of the main sectors of activity at the national level (Harbouze et al., 2019), and it contributes to nearly 38% of total employment, and nearly 73.7% of employment in rural areas and provides more than 65% of the income of rural households (Intidami & Benamar, 2020). This contributes to the fight against rural exodus and to the consolidation of the country's socio-political stability (Belmahi, Hanchane, Krakauer, et al. 2023). Agricultural land represents about 69% of the national territory. On the other hand, the livestock sector has contributed to the agricultural added value by 30,6% and it occupies the 1st place, compared to other agricultural branches in 2018 (Louali 2019). The country's livestock population is approximately 31.092 million, including 21.6 million sheep, 3.3 million cattle, 6 million goats, and 192.000 camels. This animal wealth has contributed to ensure food security of 97% for milk and 98% for red meat (MAPMDREF 2021). In fact, the livestock sector is one of the most important sectors of the Moroccan agricultural economy.

In Morocco, drought episodes have been frequent since the 1980s (Skees et al. 2001). The regions subject to drought are located in the centre of Morocco, including Saïs, Gharb, the Central Middle Atlas and the Orient, which experience long and severe droughts. On the other hand, the northern regions experience moderate and short drought periods (Chbouki et al., 1995). Drought is the major natural hazard threatening the country's resources (Balaghi, 2006; Bazza & Stockton, 1990) and it can have several impacts on agriculture, livestock, hydrology and, consequently, on the society and its economy (Hanchane, 2016; Verner et al., 2018).

The characterization of drought is possible by using climate indices (Haied et al. 2017). These indices are used to assess the intensity, duration, and severity of drought. Its impact on agricultural production has been largely elucidated by many studies in Morocco. However, its effect on livestock feeding has not been addressed by agro-climatic studies in Morocco. However, on the global scale, several research studies have been conducted. Begzsuren et al. (2004), have shown how drought and blizzard (snow and low temperature in winter) determine livestock mortality in southern Mongolia. In the US, Leister et al. (2013), used modelling to assess the effect of drought on the livestock sector. In addition, the study of Murray-Tortarolo & Jaramillo (2019) revealed that cattle and goat livestock have declined due to the drought that has hit the country. Other work, such as that of (Vetter, Goodall, and Alcock 2020), showed that commercial livestock keepers in the KwaZulu-Natal region of South Africa lost their herds of sheep, and goats, due to the impact of the drought during the 2015-2016 season. In the United Kingdom, (Salmoral, Ababio, and Holman 2020), showed the impact of drought on outdoor livestock production, and farmers' strategies to adapt to feeding crops shortages.

Thus, the aim of the present study is to evaluate the meteorological drought according to the Standardized Precipitation Index (SPI) and to measure its impact, on the one hand, on the increase of fodder and straw bale prices and, on the other hand, on the livestock reproduction.

Study Area

The province of Taza was created on 13 October 1952. It is located in the north-east of Morocco and is part of the Fez-Meknes region. Its surface area is 7098.50 km2, it has 34 rural communes and 04 urban communes (Bouchtita and Bribri 2018). On the geomorphological level, the province of Taza is heterogeneous. Its relief is a real mosaic of very diverse areas, predominantly mountainous, with altitudes ranging from 184 to 3010 m (Figure 1). The study area is in

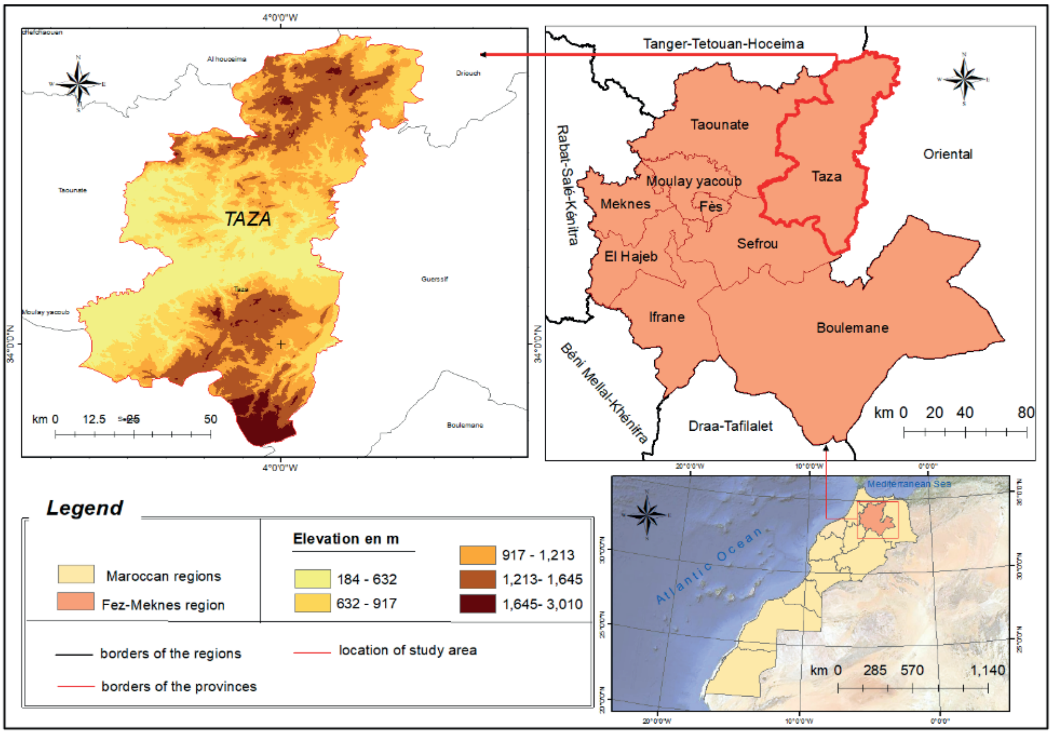

Fig. 1. Geographical location of Taza province

the semi-arid bioclimatic stage according to the Emberger index. The average rainfall is 595 mm/year.

Agriculture occupies a total area of 643.640 ha. It is the main sector of activity and the main provider of employment, offering several opportunities for investment and the creation of agro-industrial enterprises. Cereal crops, especially wheat and barley, are the main crops in the province with an area of 120.609 ha. It is ranked second in terms of cereal production, and first in terms of livestock with 897.8 thousand head in the region of Fez-Meknes (Ministère de l'Intérieur, Direction Générale des Collectivités Locales, 2015).

The province of Taza experienced a demographic decline between 2004 and 2014. This demographic decline was estimated at -0.55% (Ministère de l'Intérieur, Direction Générale des Collectivités Locales, 2015). The meteorological drought is one of the main causes of immigration from the province.

Materials and Methods

The study of meteorological drought and its impacts on livestock production and fodder prices in the province of Taza is based on two types of data: the precipitation data, used in this research is from the Provincial Directorate of Agriculture of Taza. The basic data consists of monthly rainfall records from September, 1931 to August, 2019.

After defining the dry years according to a reference period (1931-2019), the agricultural data were evaluated according to the drought intensity. These data concern the production of livestock and the prices of fodder used. They are collected from a field survey based on a sample of 100 livestock breeders in the province of Taza. This population was interviewed, using a questionnaire that was completed as part of our fieldwork. The study was conducted between April and August, 2020. The questionnaire included statistical data on herd size, straw bale price, types of fodder consumed and their prices, duration of consumption, livestock prices in dry and wet years, number of deaths and births, livestock sales markets, and the nature of public support in dry years.

The SPI is an index, recommended by the World Meteorological Organization that can assess drought at different time scales: 3, 6, 12, 24 or 48 months (Byakatonda et al., 2018; Jain et al., 2015; McKee et al., 1993). This index defines drought severity in different classes (Table 1) and is expressed as follows (Jarju & Solly, 2020; Yerdelen et al., 2021):

$$SPI = \frac{(Pi - Pmoy)}{\sigma},$$

where SPI: standardized precipitation index; Pi: annual precipitation; Pmoy: average annual precipitation (mm) and σ: standard deviation (mm).

Table 1. Classification of drought in relation to SPI value (McKee et al., 1993)

Classes	SPI values
Classe 1 : Extremely wet	≥ 2
Classe 2 : Very wet	1 to 2
Classe 3 : Moderately wet	0 to 1
Classe 4 : Mild drought	0 to -0.99
Classe 5 : Moderate drought	-1 to -1.49
Classe 6 : severe drought	-1.5 to -1.99
Classe 7 : extremely dry	≤ -2

Results

Frequency and intensity of annual meteorological drought in Taza according to the SPI

According to the reference period analyzed (1931–2019), the results of the calculation of the 12-month SPI showed a seamed wet phase of 5 successive years from 1937–1938 to 1941–1942, followed by a long phase of mild drought, extended over 8 years from 1942–1943 to 1949-1950. But from 1950–1951, until the 1972–1973 season, there is an alternation of dry and wet years. Then, a short wet period of 5 years from 1973–1974, to 1977–1978, was followed by a very long dry period of 15 years from 1978–1979, interrupted by two wet years. The end of this phase recorded a record negative SPI of -1.70. After this long dry period, 3 successive wet years from 1995–1996 to 1997–1998 were recorded, followed by three continuous wet years from 2008–2009, to 2010-2011, which was characterized by a record positive SPI of 3.16 in 2009-2010. There was also no extreme drought (SPI >-2) in the study area during the period analyzed.

The SPI shows an alternation of dry years (57%) and wet years (43%), with a relatively high frequency of occurrence in slightly dry years (80%). However, moderately wet years constitute 26%. On the other hand, the strongly to extremely wet years are equivalent to 17% and are gathered during the period 1990-2015. On the other hand, the degrees of extreme droughts are practically nil (Figure 2).

Impact of drought on livestock activity

Impact on the price of the straw bale

The price of the straw bale during the production period (June), in a wet year is lower in the province of Taza due to the increase in supply. On the other hand, it increased by 221% in the case of a moderately dry year and by 542% in the case of a very dry year, such as the 1994–1995 campaign; the price oscillates between 7 and 45 MAD (Figure 3).

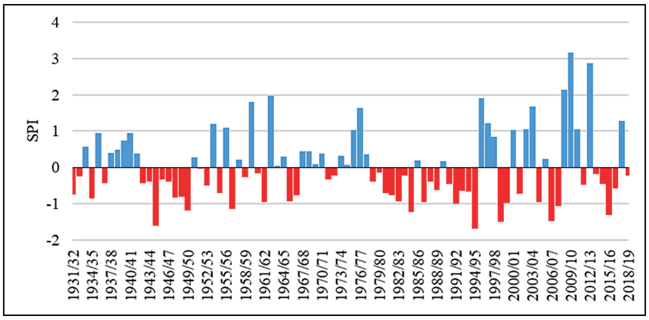

Fig. 2. Annual SPI values at the Taza rainfall station (1931–2018)

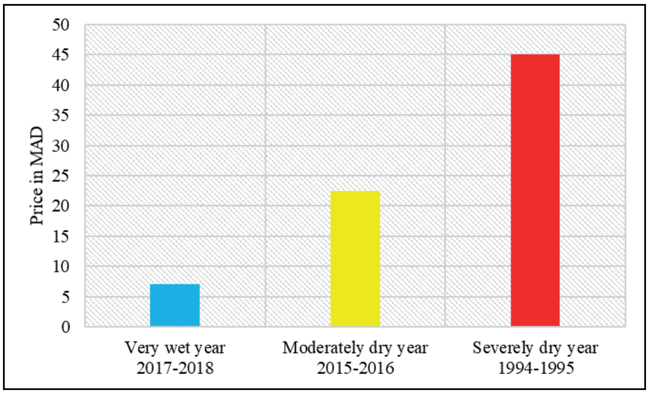

Fig. 3. Evolution of straw bale prices in MAD according to the year's climatic situation

Data source: Field Survey, 2020, 1USD = 10.16 MAD

Impact on fodder prices

Climate drought has a definite impact on fodder prices. The price of a 40 kg bag of wheat bran has increased by 25 to 40 MAD, when comparing the wet agricultural year (2017-2018), with the moderately dry agricultural year (2015-2016). Thus, the price of feeding barley in turn experienced an increase of 20 to 40 MAD. However, the price of fodder maize recorded a slight increase compared to the price of barley and wheat bran; it fluctuated between 5 and 15 MAD for each bag of 40 kg (Figures 4, 5 and 6).

We note that prices for all three feeding crops increase slightly during the late autumn and winter season although 2017-2018 was classified as a wet year. Also, the price gap becomes significant during the spring and summer season, especially for barley and wheat bran. In contrast, the price of maize has shown slight variability due to its marginal place in livestock feeding. In addition, we notice that breeders are reducing the number of livestock in order to adapt to the increase in fodder prices.

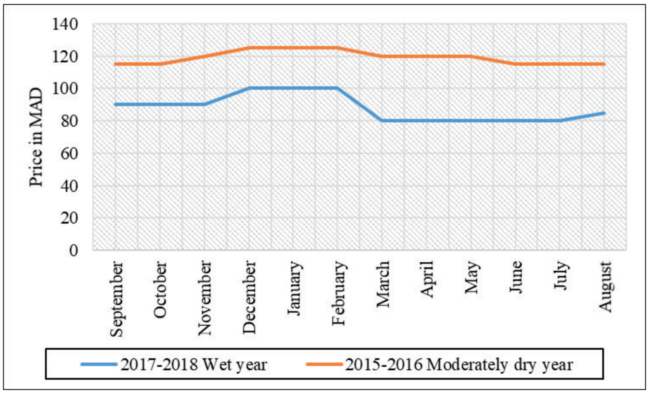

Fig. 4. Evolution of wheat bran price (MAD/40 kg) in a wet year compared to a moderately dry year

Data source: Field Survey, 2020 / 1 USD = 10.16 MAD

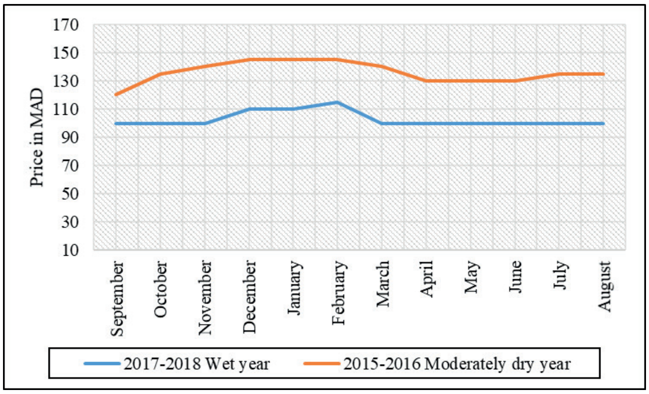

Fig. 5. Evolution of barley prices (MAD/50 kg) in a wet year compared to a moderately dry year

Data source: Field Survey, 2020 / 1 USD= 10.16 MAD

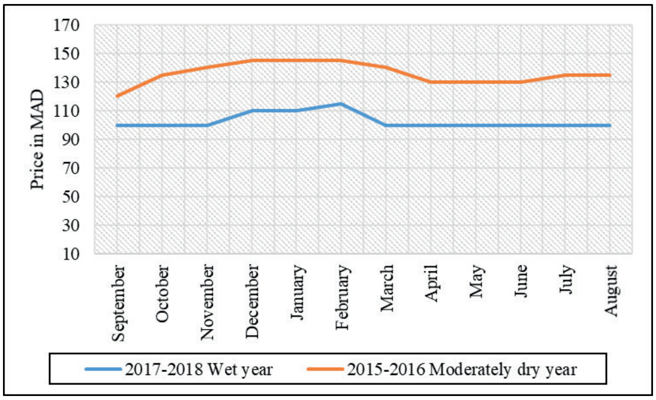

Fig. 6. Evolution of the price of maize (MAD/40 kg) in a wet year compared to a moderately dry year

Data source: Field Survey, 2020) / 1 USD = 10.16 MAD

Table 2. Comparison of livestock prices in MAD between a very wet year, a moderately dry year and a severely dry year and the percentage reduction in prices in Taza province

Price in MAD And Type of livestock	Price in MAD in the very wet year (2017–2018)	Price in MAD in the moderately dry year (2016–2017)	Price in MAD in the severe drought year (1994–1995)	% Reduction between very wet and moderately dry year	% Reduction between very wet and severely dry year
Dairy cow (improved breed)	17000	10000	3000	25.9	70.0
Calf (improved breed)	7500	5500	1400	15.4	68.5
6 month old lamb not fattened (improved breed)	900	650	400	16.1	38.5
6 month old fattened lamb (improved breed)	1600	1050	550	20.8	48.8
Male sheep, one year old, fattened (improved breed)	2500	1800	1100	16.3	38.9
Fattened he-goat (improved breed)	1600	1200	700	14.3	39.1
6 month he-goat (local breed)	850	600	350	17.2	41.7

Data source: Field Survey, 2020 / 1 USD= 10,16 MAD

Impact on livestock prices

Overall, the price of livestock decreases in proportion to the severity of the drought; it varies between 14% and 70%. On average, the reduction in prices is 18% between very wet and moderately dry years, while it is 49.3% in extremely dry years. The largest reductions are for improved breed calves and dairy cows, which are the livestock most affected by the meteorological drought. For the rest of the livestock, the sensitivity of their selling prices to the climate remains almost equal and of low degree (Table 2). The decline in prices for male sheep stock, cows and he-goat is a consequence of the liquidation of livestock to reduce the expenses of breeders, especially after the increase in feeding crops prices.

Impacts on livestock fecundity and mortality

Sheep fecundity is considerably sensitive to meteorological drought in the province of Taza; it is reduced by about 50% in the case of an extremely dry year, as was the case in the 1994-1995 agricultural year. Conversely, mortality increased by 6 times due to the severity of the drought. These mortalities are observed mainly in newborn and older ewes. We also note from our observations in the field that the threat of disease and death increases in response to drought (Table 3).

Discussion

This agroclimatic study is devoted to the study of the relationship between climate variability and cereal yield, on the one hand, and livestock, on the other. It is carried out in the Province of Taza, in the North-East of Morocco, with a semi-arid Mediterranean climate. This province is marked by the dominance of rainfed cereals, especially wheat and barley, and the importance of livestock in the economy of the local population.

Precipitation is characterized by a very significant inter-annual fluctuation, where the coefficient of variation reaches 32%. The non-parametric Mann-Kendall test applied to the period studied from 1931 to 2019, shows an annual downward trend in precipitation of -0.16, against -0.89 for the month December which is the rainiest month during This reduction in annual precipitation results in an increased frequency of drought, which is consistent with the general consequence of global warming (Pörtner et al., 2022). This reduction in precipitation is linked to increase in the frequency of the positive phases of the North Atlantic Oscillation (NAO) (Belaassal 1998; Delannoy 1988; Driouech et al. 2020; Filahi et al. 2016; Hanchane and Bijou 2018; Jarlan et al. 2014; Sebbar 2013).

The temporal analysis of climatic drought through the standardized precipitation index (SPI) during the period studied indicates that this risk is more recurrent in the province of Taza, with the dominance of slightly dry years. This result is in agreement with those obtained by several authors (El Hafid, Zerrouqi, and Akdim 2017; Hanchane 2016; Kessabi and Mohamed 2020; Skees et al. 2001), who have shown that drought has imposed itself with force since the eighties.

Table 3. Percentage of fecundity and mortality according to drought intensity, %

	Very wet year (2017–2018)	Moderately dry year (2016–2017)	Severely dry year (1994–1995)
Fecundity	94	78	50
Mortalities	6	20	37

Data source: Field Survey, 2020

Indeed, these climatic conditions have had a negative effect on livestock activities. On the other hand, the fall in rainfall in the spring season is insufficient for the grass to grow and survive longer. It quickly withers, because of the high temperature during this season, due to the predominance of the hot season, which sets in from the end of spring and extends until summer and the beginning of autumn (Deitch, Sapundjieff, and Feirer 2017; Lionello et al. 2006). Especially, since it starts early on the southern shore of the Mediterranean Sea, where the province of Taza is located. This situation puts breeders in a big dilemma, because they are forced to use fodder feed and the bale of straw even at the end of winter until spring and summer, contrary to the usual situation in wet years, where these foods are used exclusively in late fall and early winter. In addition, this unforeseen climatic anomaly causes farmers to ration the use of stored feed. But given the small amount of food, this solution does not work, especially during extremely dry years such as the 1994-1995 agricultural campaign.

It appears from the analysis that during the drought period, determined using the ISP, the province of Taza experienced huge crop losses, where the yield of barley, which is used as food for livestock, reached 2.5 q /ha during the 1994-1995 agricultural year, classified as severely dry, and 5.6 q[1]/ha during the 2015-2016 agricultural year, which was classified as moderately dry. On the other hand, the rainy years did not allow herders to compensate for the losses, since the risk of drought often returned after a year or two. Indeed, climatic drought seriously affects the fodder grain sector, and consequently the livestock sector. Feed prices have increased significantly, for example the price of a bale of straw has increased by 221%. However, the price of barley increased by 23% in the slightly dry year of 2015-2016, compared to the wet year of 2017-2018. The relatively small increase in the price of feed barley, compared to the price of straw bales, during slightly dry years, can be explained by imports of barley to compensate for the deficit in national production. In addition, the reproduction rate of the herd, the size of the herd and their price in the market decrease. The decrease in reproduction, especially for sheep and goats, is due to thermal and water stress during dry years, which affect milk production for ewes, which increases their mortality, and consequently reproduction. Similar links between climate and livestock variability have been established in other regions of the world. For example, in Mexico the drought led to the decrease in the size of cattle and goats by 3% after the worst drought that hit the country in 2011-2012 (Murray-Tortarolo & Jaramillo, 2019). In Mongolia, drought and blizzard (snow and low temperature in winter) determine livestock size, where mortality reaches 18% (Begzsuren et al., 2004). In the United States (Leister et al., 2013), drought conditions in 2011 and 2012, have also been confirmed to have reduced yields of winter cereals, spring cereals, and pasture supply, which has caused the price of fodder to rise.

It is noted that the drought led to an increase in the slaughtering of dairy cows, which caused a drop in the price of cattle and a more rapid decline in the breeding herd. In addition, this liquidation of cows has led to the regression of milk production and the intensive sale of their meat in butcher shops and local rural markets, due to its low price, instead of meat from fattened bulls and sheep, which are very expensive. Our result is identical to that obtained by Salmoral et al. (2020) in the UK, by Leister et al. (2013), in the United States and by Bahta (2020) in South Africa.

The results of this study show that rural exodus is mainly due to climatic drought. It is noted among some small breeders, due to the recurrent drought since the last decade of the 20th century, and during the studied period of the 21st century (1992, 1993, 1995, 1999, 2001, 2005, 2007, 2012, 2016), that they sell their livestock and migrate to cities, where they settle in shantytowns and work in informal activities. Others have become workers in the construction sector, or workers in the modern farms of large landowners in the province of Guercif, the province of Berkane in eastern Morocco and in the province of Meknes in the center-west of Morocco. As for breeders, who have sons engaged in the army, or in the public service, they have settled in the towns and opened commercial shops. But in recent years, the economic hub of Tangier has also become a pole of attraction for these environmental migrants. Regarding the medium and large breeders, they are still resilient and face the climate during the dry years. Therefore, small farmers are extremely vulnerable to drought, due to the limited resources at their disposal. This result is further confirmed by Bahta (2020). Therefore, the livestock sector contributes to the social and spatial stability of the rural population.

Conclusion

This study has shown that the province of Taza has experienced six periods of meteorological drought that are characterized by a mild to extreme severity during the years 1931-1937, 1942-1950, 1978-1985-, 1986-1989, 1990-1995 and 2013-2017. Indeed, meteorological drought constitutes a recurrent risk in this province, as it is the case for the whole of Morocco. The agricultural year of 1994-1995 is the driest year with a record negative SPI of -1.70.

By analyzing the impact of drought on livestock ac-

[1] 1 quintal=100 kg

tivity, according to a case study, based on field surveys, it is observed that it can lead to a decrease in the number of livestock due to mortalities, that can increase by 6 times in extremely dry years, mainly in newborn and older ewes. Added to this is the decrease in reproductive performance by 50%. Also, the sensitivity of fodder prices to the onset of drought is noted. Similarly, the decline in livestock prices is proportional to the severity of the drought for improved calf breed and dairy cows. This situation has prompted breeders to sell their livestock in local markets, as an adaptation to the drought, especially as the State leaves them under the mercy of natural conditions.

Conflict of interest

All authors declare no conflicts of interest in this paper.

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