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CLIMATE CHANGE AND DECISION SUPPORT USING THE COMPUTER TOOL INSTAT FOR EL GANZRA REGION, MOROCCO

SUMMARY

If the scarcity of water resources and their limitation is a characteristic of the climate of Morocco, this phenomenon seems to know a distinct accentuation during the last decades. But, on the other hand, the scarcity of this resource and the drought are the main constraints of agricultural production; the situation then is more alarming. Although scientists in the region have developed many technologies to cope with these environmental problems, the difference between the yields achievable by farmers and the potential yields generally remains huge in rainfed and irrigated areas.

This paper develops the problem of rainfed agriculture in the Khemisset region, El Ganzra site, in the constraining context of climate change and natural resources degradation. Indeed, several measures are necessary to cope with these climate changes; therefore, we propose a method of agro-climatic analysis of the first significant rains. Our investigations, which are part of the decision support approach, are based on choosing the suitable period for sowing cereals using the "InStat" tool. The method used is based on a quantitative approach, allowing us to study the Spatio-temporal variability of precipitation and the analysis of drought intensity on the site. Consequently, the modelling makes it possible to propose scenarios to farmers regarding sowing dates and crop selection at the appropriate time.

Keywords: rainfed agriculture, drought, adaptation, InStat, sowing cereals, climate change, El Ganzra.

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INTRODUCTION

Climate change (CC) is one of the most pressing challenges facing humanity in the Anthropocene era (El Bilali *et al.*, 2020). CC in recent decades is a major global problem and therefore solutions are being sought to mitigate its consequences. Climate change can be manifested as a change in climate elements relative to average values or as a change in the distribution of climate events relative to average values (Simunic *et al.*, 2021).

The Intergovernmental Panel on Climate Change (IPCC) stated in 2008 that natural resources and agriculture are among the systems and sectors that are particularly vulnerable to climate change and will be strongly impacted. Globally, while average precipitation is expected to change slightly, variability is expected to increase. As a result, extreme weather events, temperature, and precipitation are expected to occur more often.

Morocco is a country of contrasting landscapes and climate risks due to a very high spatial and temporal heterogeneity of climate. Climate change will undoubtedly have essential consequences in agriculture on crop yields, the distribution range of cultivated species, irrigation water availability, and ecosystems' fragility. Climate projections (Ait-El-Mokhtar *et al*., 2022) indicate that aridity will progressively extend due to decreasing rainfall and increasing temperature. However, climatic hazards make agricultural production conditions increasingly difficult (Aziz, 2022). Therefore, the production loss proves to be high and not negligible as it is predicted to obtain between 5.5 and 8.0% reduction in grain yield (Balaghi *et al.*, 2010). Consequently, climate change will exacerbate the degradation of resources vital to agriculture, mainly water, soil, and agrobiodiversity. Thus, climate change will exacerbate the degradation of resources vital to agriculture, mainly water, soil, and agrobiodiversity.

This climate change impacts human activities and cropping systems. The biological relationship between harvesting and climatic conditions makes agriculture the first activity affected by this phenomenon. This impact differs from one area to another, and the consequences are not felt in the same way throughout the world (Chakirou, 2005). Gommes *et al*. (2009) showed that climate change would negatively affect Moroccan agriculture in the coming decades. Due to climate change, these impacts will be particularly pronounced in rainfed agriculture, where most small farms are concentrated. This is essentially subsistence family farming, with low resilience to climate change.

Since 2013 Morocco has continued the development of its national environmental legal framework apace, with major updates to its primary legislation on water (Law No. 36-15 published in 2016), the coastal zone (Law No. 81-12, of 2015), and on the environmental assessment (Law No. 49-17, passed in July 2020). New laws on waste, climate change, access to genetic resources and the fair and equitable sharing of the benefits arising from their use are being developed. A swathe of regulatory improvements is being considered, with laws being drafted, including for protected areas and climate change. The law’s purpose is to: (a) Strengthen the protection and conservation of resources and the natural environment, biodiversity and cultural heritage and prevent and combat pollution; (b) Integrate sustainable development into sectoral public policies and adopt a national strategy for sustainable development; (c) Harmonize the national legal framework with international conventions and standards; (d) Strengthen measures to mitigate and adapt to climate change and to combat desertification; (e) Decide on institutional, economic, financial and cultural reforms in environmental governance; (f) Define stakeholder commitments in matters of environmental protection and sustainable development; (g) Establish an environmental responsibility regime and an environmental control system.

Specifically, in terms of legal reforms, the law foresees, among other developments: (1) The adaptation of the water legislation to the requirements of sustainable development and the combined effects of desertification and climate change; (2) The adoption of a targeted legal regime for the protection of soils against degradation and pollution and for optimal land use; (3) The establishment of an environmental liability regime (UNECE, 2021).

In this study, we will analyze the situation of the EL Kansera (El Ganzra) site, which is undergoing the same changes and shows increased vulnerability to CC. These conditions require better water resources management by implementing adequate adaptation strategies while allowing better planning of their actions. The study is original and the knowledge on spatial and temporal characterization of the climate is necessary to provide as technical solutions for this region. The annual rainfall received in this semi-arid region is highly variable and experiences significant fluctuations in time and space. Periods of water deficits of varying lengths can occur at any time. In this region, droughts at the end of the cycle are the most frequent, while those in the middle are rare but the most dangerous. The climatic monitoring of the agricultural season (the choice of the sowing date is a delicate decision) allows the formulation of alternative crop management proposals according to different rainfall deficit scenarios. This is only possible with a good knowledge of this environment, the characterization of the climate, and the identification of recent changes based on appropriate techniques.

MATERIAL AND METHODS

Morocco is located in North Africa and has a land area of 446,550 km². The country has a high variety of elevation from the lowest point of Sebkha Tah, 55 metres below sea level, to the highest point of Jebel Toubkal which rises to 4,165 metres. A large part of Morocco is mountainous. The Atlas Mountains are with the direction from the southwest to the northeast and are mainly located in the centre and south of the country and form a backbone of the country. The Rif Mountains are located in the North, stretching from the northwest to the northeast over the region bordering the Mediterranean Sea. Most of the southeast portion of the country is the sparsely populated Sahara Desert (UNECE, 2021).

Along the coast of Mediterranean Sea, the climate is warm, with dry summers and mild winters. Inland, the climate is more severe, getting hotter and more extreme closer to the Sahara Desert.

Figure 1. Detail of a physical space in central part of Morocco

(Photo: Spalevic, December 2017)

On the Atlantic Ocean coast, Morocco's capital of Rabat has an average January low temperature of 8℃ and an average July high temperature of 28℃. By contrast, the city of Marrakesh, which is located farther inland, has a January average low of 6℃ but a much-elevated average July high temperature of 37℃. Average annual precipitation can reach to more than 1,000 mm in the mountainous areas of the North but is less than 300 mm in the basins of the Moulouya, the Tensift, the Souss-Massa; and areas south including the Atlas Mountains and the Saharan zone. Typically, there are two rain periods per year, one in the fall and one in winter. The annual number of rainy days varies from about 30 in the South of the country to near 70 in the North. (UNECE, 2021).

The study area is located 40 km northeast of Khemisset city, the El Ganzra site, which straddles the Sidi Slimane plain, and the pre-Rifian marly hills (34°02'31.6"N 5°55'27.7"W; 34.042117, -5.924363).

This area is characterized by altitude variations (the western part is at 207m, the eastern part is at 259m, 300m in the southern position, and 473m in the northern part). Therefore, we note a north-south and east-west decrease in altitude. The site's climate is semi-arid, and the rainfall and thermal regimes with two distinct seasons: the dry season begins in May and ends in September (5 months), and the wet phase begins in October and ends in April (7 months). The annual rainfall average is 464 mm, and the yearly temperature average varies between 7.4°C to 35.4°C; sometimes, the temperature can reach 46°C.

The study area remains, despite its topography generally uneven and with its important geographical location rich in water resources, it is at the intersection of two basins among the largest in Morocco, Sebou and Bouregrag. Thus, the water table of this site is under the administration of two Water Basin Agencies (ABH): Sebou and Bouregrag. We can also distinguish permanent and temporary or intermittent watercourses. In addition, the most widespread vegetation cover is the reforested forest consisting mainly of secondary species of Eucalyptus trees, and wild olive trees named "Jebbouj". The forest of El Ganzra extends over an area of 930 ha is an important grazing site for the breeding of forest livestock of secondary species. The main economic activity is agriculture with a useful agricultural area UAA of 15117 ha, of which cereal constitutes 71%, insofar as it employs a significant portion of the population. However, this sector remains highly dependent on climatic hazards.

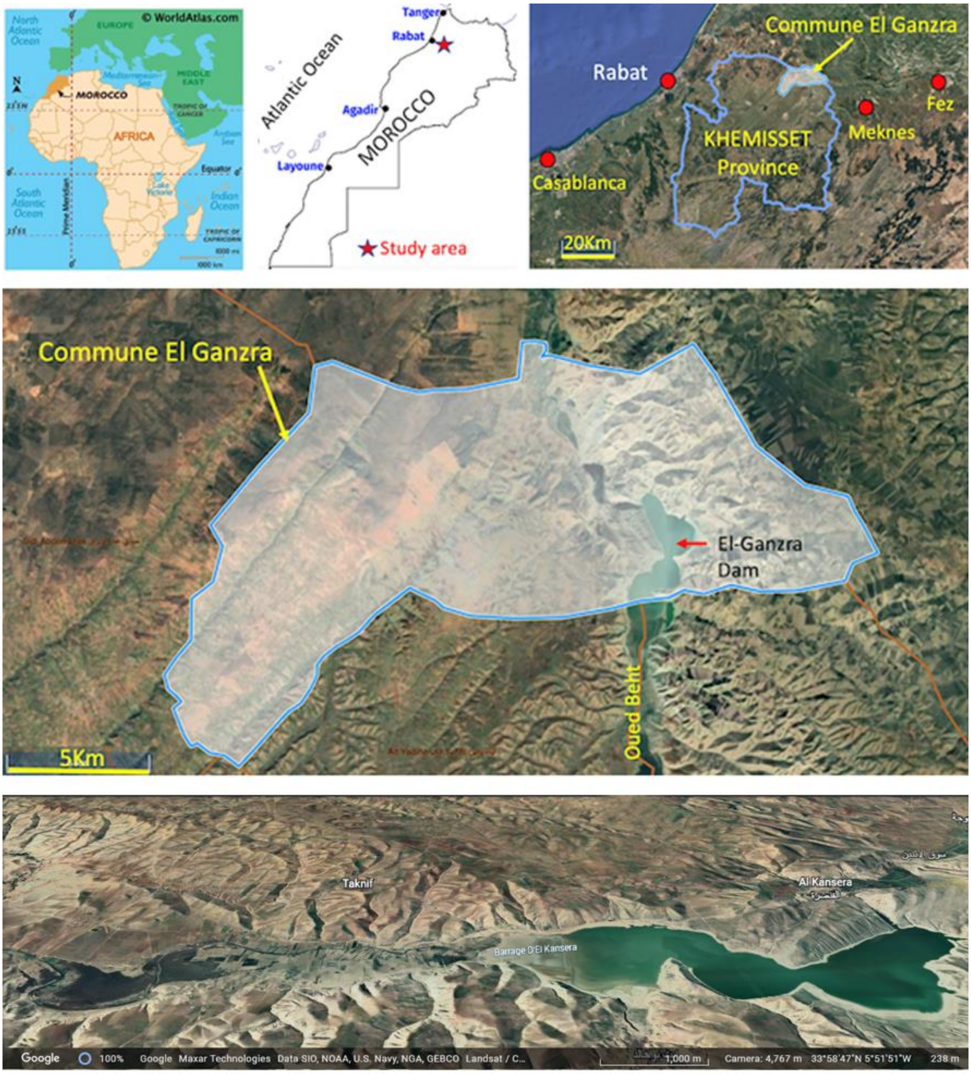

Figure 2. The Study Area
(Source: report, Khemisset Urban Agency, 2016 and Google earth 2022)

Study of climate variability. As far as the climatic data are concerned, they have been obtained from multiple sources (National Meteorological Directorate, Hydraulic Agencies). Our investigation will analyze the available data (rainfall, maximum and minimum temperatures, potential evapotranspiration, and other related indices) on the El Ganzra region to find and characterize these changes. The rainfall variability will focus mainly on determining the central tendency and dispersion parameters and highlighting the trends.

Figure 3. Panoramic view on the Al Qansra dam (Source: Google)

- Central tendency parameters: The arithmetic mean was calculated over a 76-year series. It is obtained by summing the distinct values observed, each of which is assigned a weight equal to its frequency (Vessereau, 1947; Aston *et al.*, 2022). The mean $\bar{X}$ identified the different rainfall rhythms that indicate the trend of decreasing or increasing rainfall; the mean fields identify the surplus and deficit periods. Thus, the analysis of these data allowed us to characterize the rainfall evolution.

- Dispersion parameters: We calculated the dispersion parameters from the mean fundamental central tendency parameter. These dispersion parameters are the standard deviation and the coefficient of variation. The Coefficient of Variation is the most widely used means of testing and quantifying the variability of a reality or a statistical phenomenon. It is the ratio of the standard deviation to the mean, expressed as a percentage (Houndénou, 1999; Vissin, 2007; Lokossou *et al.*, 2020). The coefficient of variation is used to compare the degree of variability of rainfall in space. The standard deviation is used to assess the absolute dispersion of values around the central value (Vissin, 2007). However, dispersion parameters alone are not sufficient to measure variability because they do not describe rainfall and hydrometric series (Vissin, 2007). Thus, to better characterize variability, the standardized precipitation index is necessary.

- Standardized Precipitation Index (SPI): From the standard deviation, the Standardized Precipitation Index or (SPI, equation 1) represent the cantered anomalies reduced rainfall inter-annual, was calculated (Bergaoui & Alouini, 2001; Docheshmeh Gorgij *et al.,* 2022). The following equation calculates the anomalies:

$$SPI = \frac{(\boldsymbol{Xi - Xm})}{\boldsymbol{Si}} \qquad (1)$$

where:

SPI: The Standardized Precipitation Index,

Xm: the average annual rainfall observed for the given statistical series,

Xi: the cumulative rainfall for a given year I,

Si: the standard deviation of the annual rainfall observed for a given statistical series.

Depending on the value of the SPI, a distinction is generally made between positive values (SPI>0) and negative values (SPI<0). We used The SPI to determine the indicators of rainfall variations and specifically the years marked by a rainfall surplus or deficit in the study area.

- *Aridity index*: This index, sometimes called De Martone’s drought index, is the ratio between the mean annual values of precipitation (P) and temperature (T) plus 10°C (De Martonne, 1926). It’s defined by the following equation:

$$I = \frac{P}{T+10} \quad (2)$$

where:

T: average annual temperature in °C;

P: mean annual precipitation in mm.

The Aridity index can also be calculated monthly and indicates the degree of dryness with the average evaporative demand of the atmosphere approximated by the temperature. The aridity increases when the value of the index decreases. At the global level, (De Martonne, 1926; El Asri, Larabi and Faouzi, 2022) proposed six significant types of macroclimates ranging from the desert or hyper-arid zones (I < 5) to the humid zones with predominantly forest (I > 40). Exceptional precipitation and other aggregates characterize the hyper-arid zones.

InStat software. The main activity of the population is agriculture, with having either "Bour" or irrigated surfaces under cultivation. Bour agriculture is dependent on natural conditions: rainfall and other climatic factors, particularly temperature and wind. In this study, we simulated the decision-making for an agricultural campaign, based on daily rainfall data of more than thirty years, using the tool "InStat". It is software that allows making the decision for a crop year by processing the climatic data not only rainfall, but it also helps to rationalize its campaign for a better yield. It could also be useful in modelling for the choice of scenarios in terms of sowing dates in the appropriate time (Gizaw *et al*. 2021).

RESULTS AND DISCUSSION

Climate characterization. Agriculture in El Ganzra is rainfed agricultural production. The global evolution of rainfall was analyzed at the station of El Ganzra. The rainfall is, for the subject region and its agriculture, more important in the winter than in the summer period. The average rainfall is 464 mm. The driest months are July and August with only 1 mm. With an average of 81 mm, the month of December has the highest precipitation (Table 1).

Table 1: rainfall recorded at the El Ganzra station (Source: Climat-data.org)

	Jan	Feb.	March	Apr.	May	June	July	August	Sept	Oct.	Nov.	Dec.
Precipitation (mm)	63	55	59	46	26	7	1	1	9	43	73	81

The variation in precipitation between the driest and wettest months is 80 mm. The average annual precipitation is about 430mm. December is the wettest month.

The study area has an average annual temperature of 19.5°C. However, the yearly average temperature is 18°C. The maximum value is in August with a temperature of 35.4°C, and it can reach 46°C. The minimum is 7.4°C (Table 2).

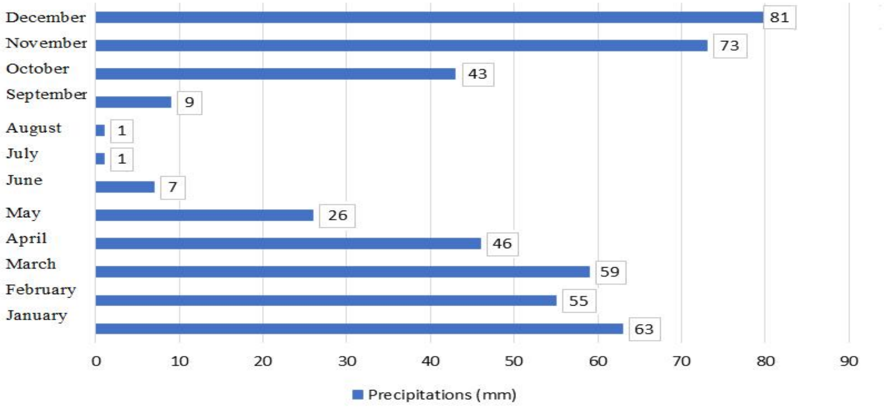

Figure 4: Annual average rainfall average at El Ganzra Station

Table 2: Annual temperature average (min. and max.) at the El Ganzra station

	Jan	Feb.	March	Apr.	May	June	July	August	Sept.	Oct.	Nov.	Dec.
Average temperature (°C)	12.2	13.3	15.7	17.7	20.3	24	26.9	27.6	24.9	21.2	16.5	13.3
Min. temperature (°C)	7.4	7.9	10	11.8	13.7	17.1	19.1	19.8	18	14.9	11.1	8.3
Max. temperature (°C)	17.1	18.8	21.4	23.6	27	30.9	34.8	35.4	31.9	27.5	21.9	18.3

(Source: climate-datat.org)

With preparing an Umbro-thermal Diagram of El Ganzra (Figure 5), there are two phases: wet and dry. Wet period is from October to April (7 months) and the Dry period is from May to September (5 months).

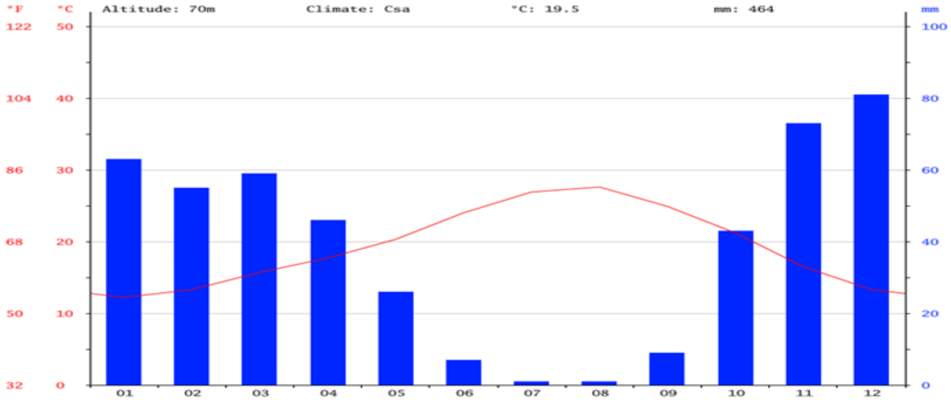

Figure 5: Two phases of dry and wet periods at the El Ganzra Commune

Emberger bioclimatic index. The Emberger bioclimatic index stands out among the bioclimatic indices traditionally used in North Africa and elsewhere in the Mediterranean (Emberger, 1931; Gaussen, 1954; Daget, 1977, and Quezel, 1979). This takes into account the annual precipitation, the average maximum temperature of the warmest month (M in °C) and the average minimum temperature of the coldest month (m in °C) (Emberger, 1955). The position of the study area (El Ganzra) on the Emberger Bioclimatic diagram indicates that this area is under Semi-Arid climatic conditions as presented in the Figure 6. (Siba *et al.*, 2022; Vessella and Schirone, 2022).

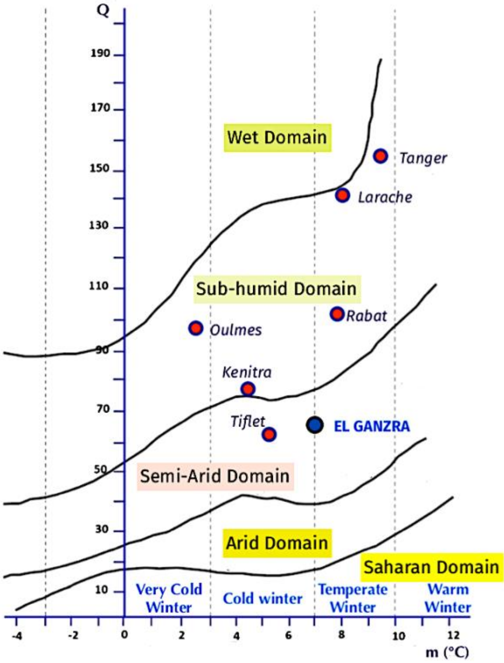

Figure 6: Location of the El Ganzra site on the Emberger diagram

The Emberger bioclimatic index is expressed by the equations 3 and 4, as follow:

$$Q2 = \frac{2000 \times P}{(M+m+546.40)\times(M-m)} = 44.15 \quad (3)$$

Stewart corrected this equation as follow:

$$Q2 = \frac{3.436 \times P}{(M-m)} \quad (4)$$

where:

P: annual rainfall in mm = 364.2mm

M: the maximum temperature of the hottest month in °C usually (July) in our case is August is 35.4°C; m: the minimum temperature of the coldest month in °C (January) is 7.4°C.

For m = 7.4 °C corresponds to a precipitation of 63 mm, then the point of intersection whose coordinates are (7.4, 63) is the semi-arid bioclimatic.

The De Martone's Aridity Index. According to De Martone's table of classes, the Aridity Index of the site El Ganzra is located between 10 and 20 (table 3). Therefore, its climate is semi-arid, and its bioclimatic stage type of climate occupies 25% of the surface of Morocco.(Elyagoubi and Mezrhab, 2022). The De Martone's Aridity Index is (equation 2):

I = 12.36 (with P=364.2 mm, and T=19.47 °C)

Table 3: Importance of climate classes according to the De Martone Aridity Index

Class	Climate Types	% Total Moroccan Area
> 20	Humid and Sub-Humid	11
10 to 20	Semi-Arid	25
5 to 10	Arid	11

Drought intensity. The climate deficit is the second side of the same coin "drought", it is calculated using the following formula:

$$Dc = P - PET \qquad (5)$$

where Dc is Climatic deficit (drought); P is Mean annual precipitation; PET is Potential Evapotranspiration.

Potential evapotranspiration (PET, expressed in mm) is a concept defined by Thornthwaite (1955); and is expressing the quantity of water that would evaporate from the soil and be transpired by the vegetation if there were no water supply problems. It is therefore independent of the actual water availability of the soil. It depends only on the capacity of the ambient atmospheric environment to induce evapotranspiration and thus mainly involves energy indicators. The Thornthwaite TPE formula is defined by the following equation:

$$\text{PET} = 16 \times \left(\frac{10 \times T}{I}\right)^{\alpha} \times K \qquad (6)$$

where PET is Potential evapotranspiration; T is Average temperature of the month considered, expressed in ° C.

To calculate I and α we use the Naoura method (Naoura, 2012, 2021) as follow:

I: The sum of the monthly thermal indices : $I = \sum i = \sum_{i=0} \left(\frac{T}{5}\right)^{1,514}$ (7)

α: Coefficient expressed as a function of the sum of the monthly thermal indices:

$10°\text{C} \leq \text{I} \leq 80°\text{C}: \alpha = \left(\frac{1,6 \times I}{100}\right) + 0,5$ (Naoura, 2012) (8)

K: corrective factor depending on the month (m) and the latitude: In our case the result are as follow (table 4):

Table 4: The PET parameters calculation per month

	Jan	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
T°c	12.2	13.3	15.7	17.7	20.3	24	26.9	27.6	24.9	21.2	16.5	13.3
K	0.88	0.85	1.03	1.09	1.2	1.2	1.22	1.16	1.03	0.97	0.87	0.86
I	3.86	4.40	5.65	6.78	8.34	10.75	12.78	13.28	11.37	8.91	6.10	4.40
PET	22.69	26.15	44.50	60.18	87.70	123.53	158.59	158.93	114.32	77.47	41.61	26.46

I = 96.61; a = 2.045784182; PET total = 942.14; PET average = 78.53; (Source: the Charles Warren Thornthwaite formula)

Finally, by using equation (5): DC = 464 – 942.14 = -478.13 mm

Interpretation. The climatic deficit of a value of -478.13 mm per year reflects the degree of dryness, taking into account the evapotranspiration, which also aggravates the already semi-arid climatic situation, which implies that the site el Ganzra is a sunny site and which knows a temperature always high, an important evaporate activity, in spite of its humid microclimate, especially for running or stagnant waters.

Standardized Precipitation Index (SPI). Taking into account the drought that can be studied only in a wide Spatio-temporal extent, in our case we will be interested in a geographically limited site "spatial entity" well determined, but a temporary extent of up to 31 years (with daily, monthly, annual data missing, some of which are calculated by the method of averages and the others have been neglected not to falsify the results).(Cerpa Reyes, Ávila Rangel and Herazo, 2022) We use the following equation:

$$SPI = \frac{Xi - Xm}{Si} \qquad (9)$$

where: SPI : Standardized Precipitation Index; Xm : the average annual rainfall observed for the given statistical series; Xi : the cumulative rainfall for a year i, Si : the standard deviation of annual rainfall observed for a given statistical series.

Depending on the value of the SPI, we generally distinguish between positive values (SPI>0) and negative values (SPI<0). SPI classification according to McKee *et al*. (1993) is presented in the Table 4.

Table 4: SPI classification according to McKee *et al*. (1993).

SPI Values	Characterization	
>2.0	Extremely wet	Humidity
1.5 to 1.99	Very wet	
1.0 to 1.49	Moderately wet	
−0.99 to +0.99	Normal	**Normal**
−1.0 to −1.49	Moderately dry	Dryness
−1.5 to −1.99	Severely dry	
<−2.0	Extremely dry	

Advantage: Precipitation is the only parameter available. The index can be calculated for various time scales, and it allows early detection of drought situations and assessment of their severity. It is less complex than many other indices, notably the Palmer Drought In decks. **Disadvantage:** Therefore, it only quantifies the precipitation deficit, values based on preliminary data may change, and values will vary if the length of the survey period increases.

***Case of the last thirty-one years (31 years)*.** We considered the statistical sequence of precipitation data for the last 30 years (1979-2015), knowing that five years of data are missing, during this period[2]. The results obtained are presented in the Figure 7 and Table 5).

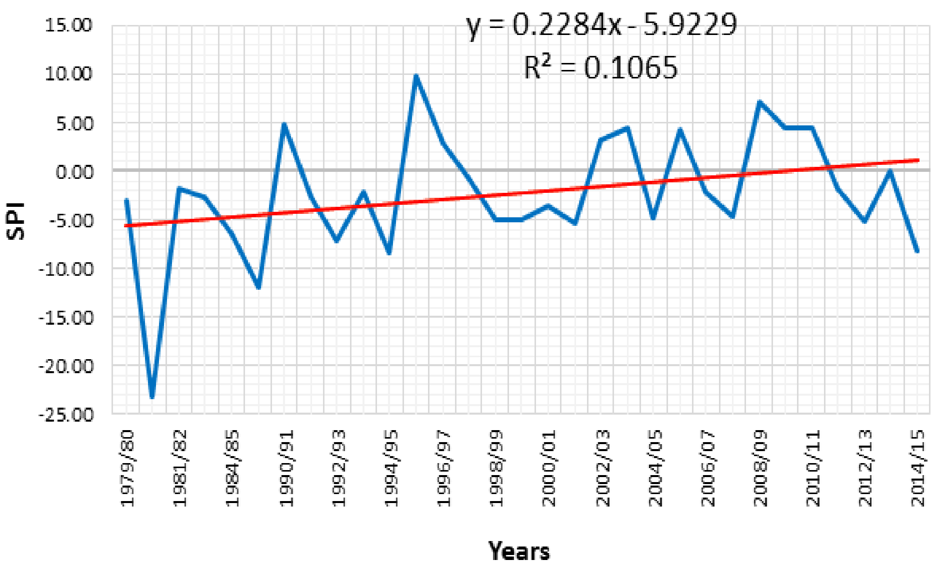

Figure 7: Standardized index of precipitations at El Ganzra station during the last 31 years (source: ABH Sebou)

The Figure 7 shows that the curve with a straight line (trend curve) is with almost zero slopes, which implies a trend for the same negative values.

Table 5: Recapitulation of the type of climate

	SE	SF	SM	HM	HF	HE
SPI	**18**	**2**	**1**	**1**	**0**	**9**
%	**58.06**	**6.45**	**3.23**	**3.23**	**0.00**	**29.03**

Source ABH Sebou

[2] Missing years are : 1982-83 ,1986-87 ,1987-88 ,1988-89, 1989-90.

We noted that the period of drought is 21 years and 11 years of the wet period, i.e., drought is dominant with a frequency of 2 years out of 3 years (64%), which confirms that the site of El Ganzra is of a dry climate, therefore is an arid or semi-arid area. The highest rainfall value was 471.55 mm recorded in 1995-1996, while the minimum value was about 122.90mm recorded in 1980-1981. This is due to the general warming that the globe is experiencing and, consequently, Morocco too. Therefore, the NAO activity (negative) will undoubtedly be the scientific explanation.

The calculation of the climatic deficit, having a consequence of hydric deficit, and the analysis of the drought index indicate that the site knows a meteorological rainfall deficit (i.e., meteorological drought). The latter will indeed impact agriculture, despite the irrigation favoured by the presence of El Ganzra dam. Furthermore, this will generate an agricultural drought, and finally, this deficit will impact the hydrology, and therefore we are facing a hydrological drought.

The site is experiencing a drought that has been raging for years in this region; can we still hope for generous rainfall for a good agricultural season, or can we anticipate and decide on other alternatives? We made a simulation to help us make the right decision using the computer tool "INSTAT" to know precisely when the sowing will start.

Apart from the relatively abundant precipitation, i.e., about 330 mm/year, temperatures can fall to low degrees during the winter months and exceed very high thresholds of 0 to 35°C.

Decision support via "InStat" in the study area. Successful seeding is a prerequisite for better grain production in the fall. Therefore, one of the important indicators affecting final yield is the seeding date. Agronomic research results have shown that early seeding allows the crop to take advantage of the season's first rains because it significantly improves fall grain yields. Indeed, the concept of first significant rainfall (FSR) could help farmers and technicians decide on planting planning. These first significant rains are expressed as the probable date of obtaining for ten successive days an amount of rain that can ensure germination and emergence based on a long series of daily rainfall data. Hence the usefulness of using an agro-climatic analysis method for FSR such as the INSTAT software.

The "InStat" software's principle consists of processing daily rainfall data over a period equal to or greater than 30 years. This processing is done according to scenarios and consists of choosing the best scenario for which the sowing will be profitable or beneficial from October, which remains the ideal month.

Hereafter, we explain the possible scenarios for which there is a cumulative rainfall of 20mm in 10 or 11 successive days. Then, there are at least 1 to 4 days of rain of the said cumulative rainfall.

The first scenario: with 10 days (Figures 8 to 11, and table 6)
Rainfall of 20 mm in at least one day: (Fig. 8)

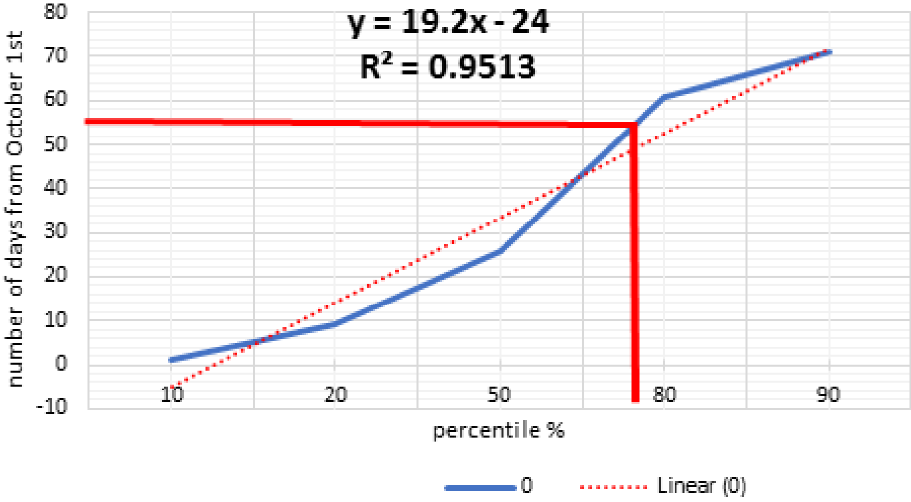

Figure 8: The day of sowing 1st case (1 day)

The value of 75% corresponds to the 55th day from October 1st, so the sowing day is November 24th, the fourth week of November.

Rainfall of 20 mm in at least two days: (Fig. 9)

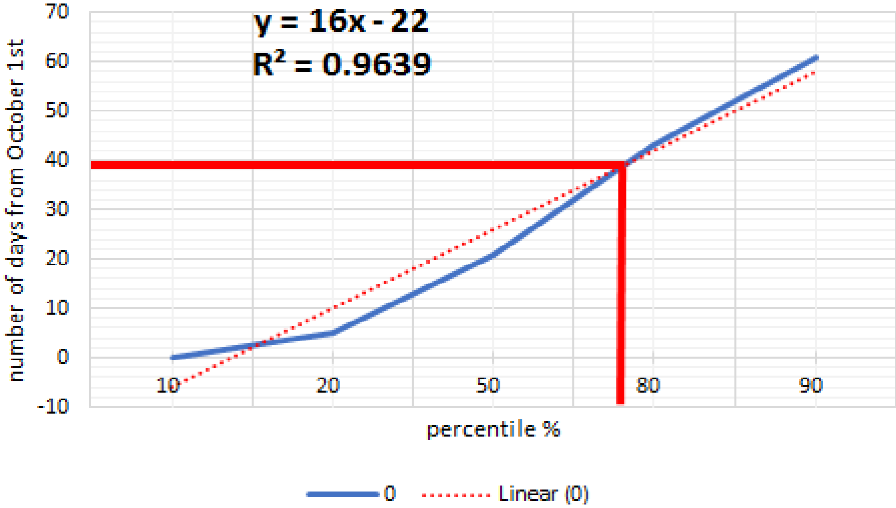

Figure 9: The day of sowing 2nd case (2 days)

The value of 75% corresponds to the 40th day from October 1st, so the sowing day is November 9th, the second week of November.

Rainfall of 20 mm in at least three days (Fig. 10):

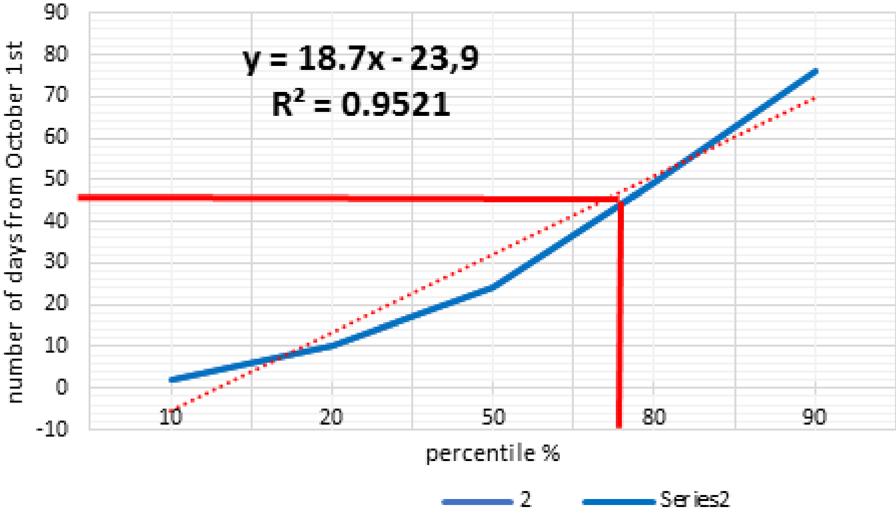

Figure 10: The day of sowing 3rd case (3 days)

The value of 75% corresponds to the 46th day from October 1st, so the sowing day is November 15th, second week of November.

Rainfall of 20 mm in four days (Fig.11)

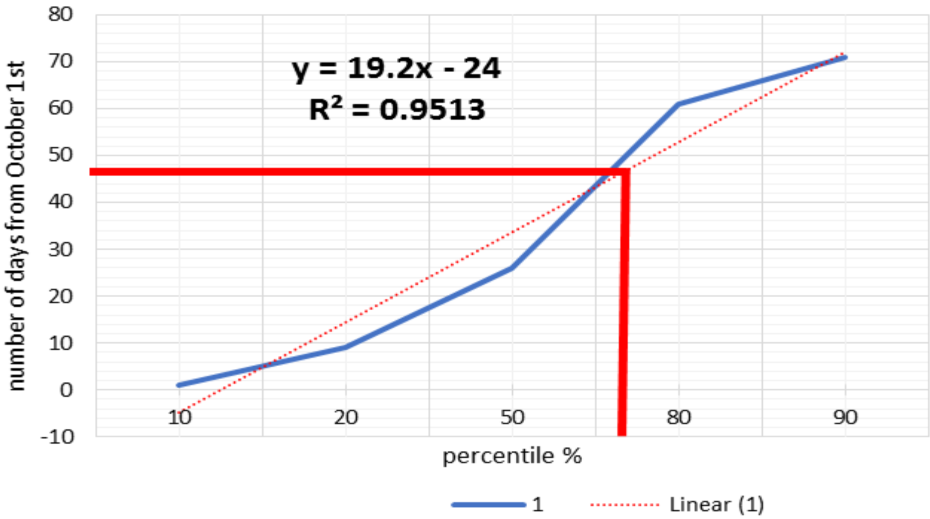

Figure 11: The day of sowing 4th case (4 days)

The value of 75% corresponds to the 56th day from October 1st, so the sowing day is November 25th, the fourth week of November.

The second scenario: with 11 days (Figs 12 to 14, and table 6)
Rainfall of 20 mm in at least one day (Fig. 12):

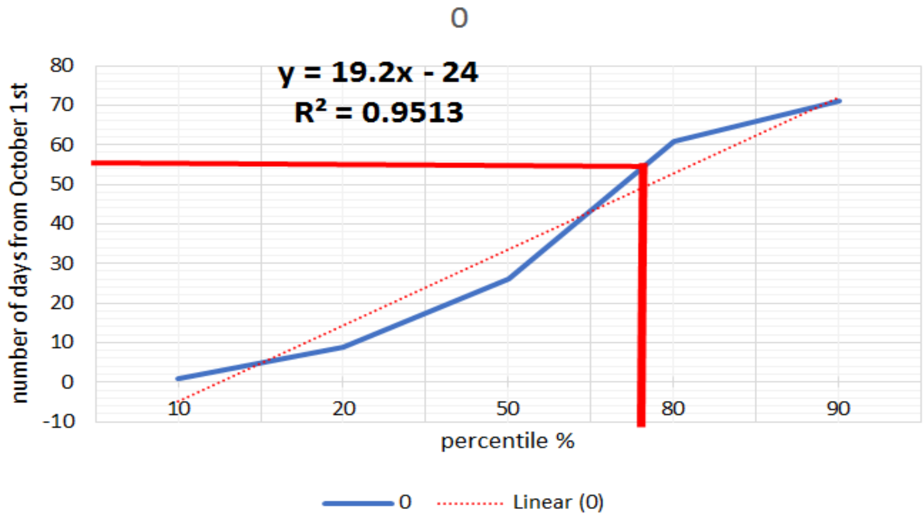

Figure 12: The day of sowing 1st case (1 day)

The value of 75% corresponds to the 55th day from October 1st, so the sowing day is November 24th, the fourth week of November. ***Note:*** Same as with 10 days.
Rainfall of 20 mm in at least two days:
Same for 11 days with at least 1 day and also 10 days with at least 1 day.
Rainfall of 20 mm in at least three days (Fig. 13):
The value of 75% corresponds to the 44th day from October 1st, so the sowing day is November 13th, second week of November.

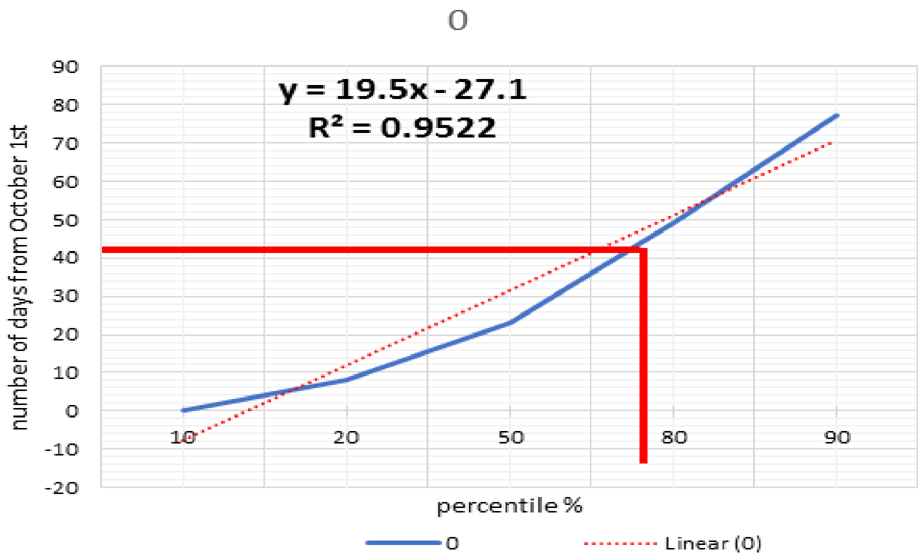

Figure 13: The day of sowing 3rd case (3 days)

Rainfall of 20 mm in four days (Fig. 14):

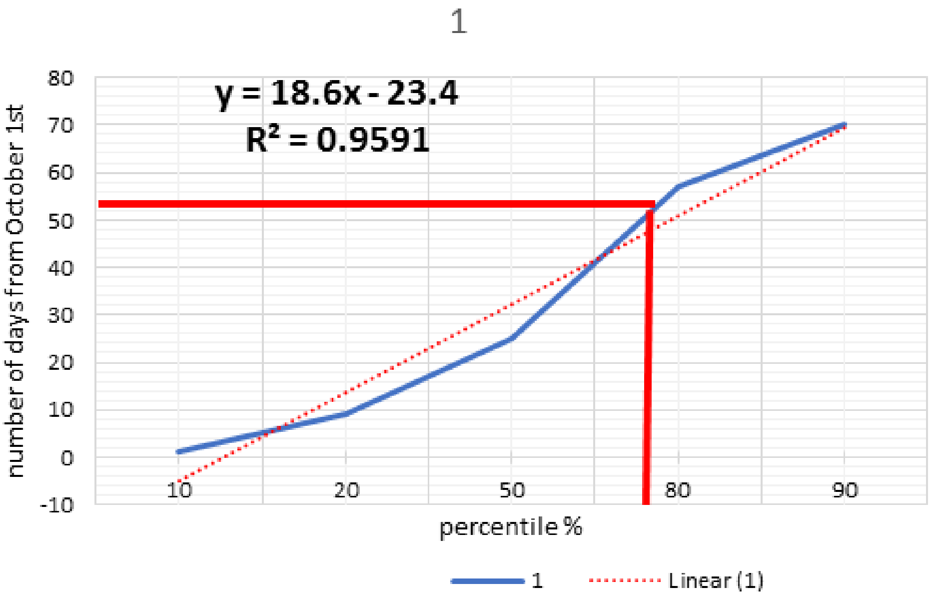

Figure 14: The day of sowing 4th case (4 days)

The value of 75% corresponds to the 53rd day from October 1st, so the sowing day is November 22nd, the second week of November.

Table 6: Summary of the results

Scenarios	**10days**			**11days**		
Numbers of days	Day. Opportunity	Correlation Coefficient	**Number of days from October**		Correlation Coefficient	Day. Opportunity
1st	24 November	**0.95**	**55**	**55**	**0.95**	24 November
2nd	9 November	**0.96**	**40**	**55**	**0.95**	24 November
3rd	15 November	**0.95**	**46**	**44**	**0.95**	13 November
4th	25 November	**0.95**	**56**	**53**	**0.96**	22 November

According to the statistical series, the best day for seeding in the first scenario is the 9th day after October (i.e., November 09). The best is the 13th day (i.e., November 13) for the second scenario. We adopt the scenario of November 9 because it has a correlation coefficient of 96%, which means the best simulation model. We are faced with an agricultural campaign that is always late, despite the right choice to start direct seeding; using new seeding techniques and irrigation to obtain a better yield, knowing that 2/3 of the years are dry.

Finally, by choosing direct seeding, one will benefit from the following advantages:

–Production costs can be reduced by about 500 Moroccan Dirhams/Ha,

–Sowing dates can be advanced by about 9 days,

–Sowing rates can be reduced by about 30,

–Yields can be significantly improved, especially in dry years.

CONCLUSION

Since climate always involves a degree of uncertainty, climate risk management is one of the characteristics of agricultural systems and their interaction with the environment in which they operate. In the face of recurrent droughts, the best agriculture techniques adapted to this environment are necessary, allowing for water-saving and efficient use.

The results show that climate change's impact on agriculture, particularly cereal production, could be more vulnerable if measures are assumed to reduce them.

The present study contributes to the knowledge of the issues related to climate change at El Ganzra and the measures proposed using the software "InStat" to predict sowing dates regarding the first significant rains. However, considerable effort remains to be made in agro-climatic modelling to develop practical and simple decision-making tools. The agro-climatic approach confirms and completes the climate analysis that highlighted the interest in adapting to climate change by considering the precocity of crop cycles. Therefore, these two approaches converge towards the same result, which is to eliminate late planting if we want to make better use of the limited rainfall resources in this area.

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