Impact of Climate Change on Cereal farming in Morocco Case study: Rommani (Rabat-region), Bouregreg watershed centre

Research Article

Impact of Climate Change on Cereal farming in Morocco Case study: Rommani (Rabat-region), Bouregreg watershed centre

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Abstract

The objective of this work to describe meteorological conditions of the areas to cereal development, for answer the effect treating problematic of climatic fluctuations on increasing, development and cereal production in Rommani (Rabat area), Bouregreg watershed centre.

This study our permit to interpret relation between cereal comportment and meteorological

conditions, using *agro-climatic* contribution and cereal development to increasing model.

A realized work contribuing the research on cereal harvest prediction and water - agricultural

management. The adoption « Crop-Syst » model would help to alert agricultural drought and cereals yields predictions In advance to quantifier.

 Key-words: Agro-meteorology, Modeling, Climate, Watershed, Cereals, Agricultural

            production Rabat-Morocco.

1. Introduction

The Intergovernmental Panel on Climate Change (IPCC) estimated in 2001 that most of the warming observed over the last 50 years is due to human-induced greenhouse gases. According to the same source, the continuation of these emissions without a serious reduction policy would increase the global temperature from 1.4 to 5.8 ° C between 1990 and 2100, and the average sea level from 9 cm to 88 cm during the same period , and would continue to increase for centuries. The hydrological cycle

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will be intensified, leading to more droughts in some areas and floods in others (Houghton 2004, Le Treut et al 2004).

The IPCC (2007) assessed available scientific information on the impacts of climate change on ecosystems, socio-economic sectors, including the food chain, water resources and human health. The agricultural sector is one of the sectors most vulnerable to climate risks

2. Material and Methods

The Agro-Climatological methodology applied in this work as tools of management and decision support is the first established on the study area "Experimental Domain of Marchouch in Rommani (CRRA, INRA - Rabat), by the work of research of my Master thesis (OUHARBA, 2011). And that I extend in the studies of perspectives in my Ph.D thesis by an assessment of water and agricultural vulnerability in the watershed of Bouregreg, in the face of climate change.

2.1. Study Site

Figure 1: geographical position of the watershed Oued Bouregreg (Google Earth)

Geographical location:

Coordinates: Latitude: 33 ° 60'41 N

Longitude: 6 ° 71'60 W

Altitude: 339 M

The rural commune of Marchouch is delimited at:

- North by the rural municipality of Sidi Bettach
- South by the rural municipality of Ezzhiliga
- East by the rural municipality of Brachoua
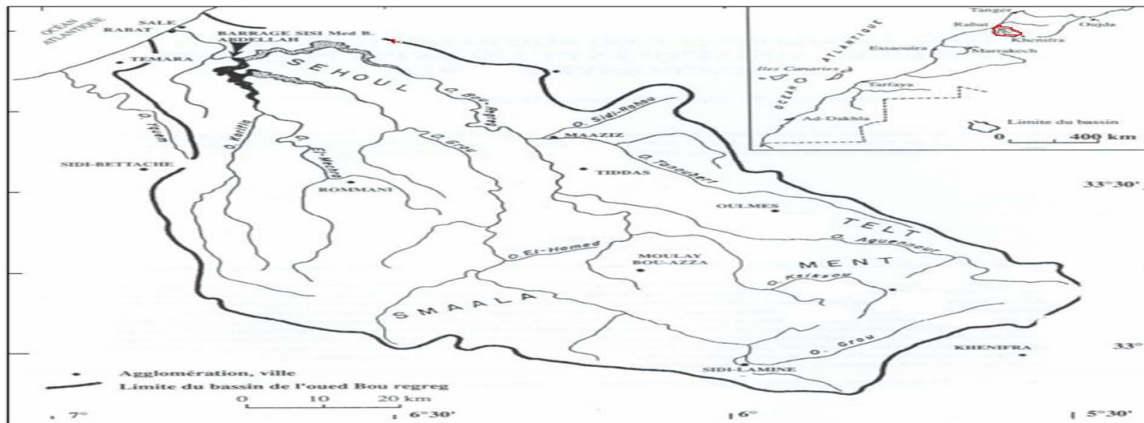- West by the rural municipality of Had Ghoualem.

Figure 2: Location of the Bouregreg Basin (El Agbani et al., 1992)
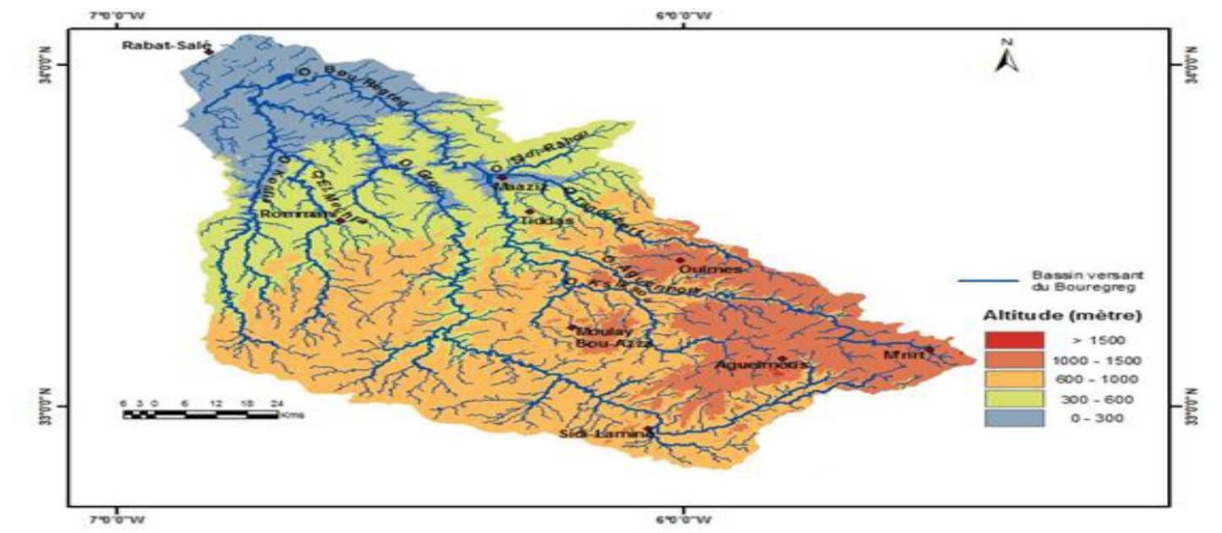
2.1.1. Topography

Figure 3: Hypsometric map of the Bouregreg watershed.

Figure 4: Overview of the topography and landscape of the Middle Bouregreg.

Table 1: Relief of the Region of Rommani

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Plain	13%	**24%**	25%	18%
Tray	81%	**27%**	27%	54%
Mountains and hills	0%	**21%**	2%	8%
Valleys and bowls	6%	**29%**	46%	20%
Area in ha	44 381	**31 631**	11 727	87 739
Area in %	51%	**36%**	13%	100%

Source: Rommani Works Center, DPA Khemisset, Rabat-Sale DRA.

2.1.2. Pedology

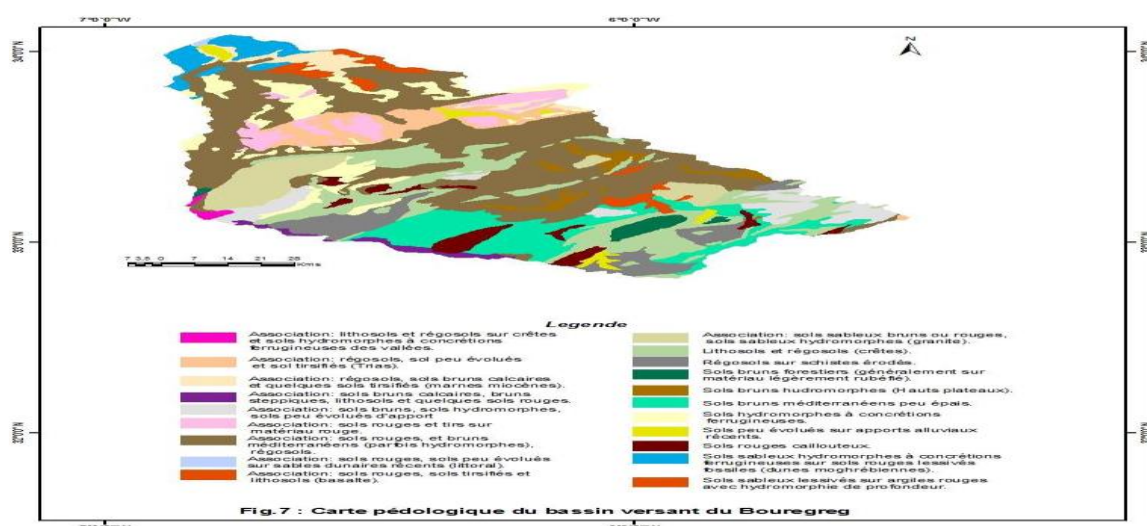Fig. 7 : Carte pédologique du bassin versant du Bouregreg

Figure 5: Soil map of the Bouregreg catchment area.

Table 2 : Rommani Soils Texture.

Floor Type	Brachoua	Marchouch	J. Moullabled	Total
Shots	15 533	**21 207**	3 987	46%
Hamri	8 876	**5 381**	3 870	21%
Rmel	0	**0**	0	0%
Hrach	19 972	**5 133**	3 870	33%
Area in ha	44 381	**31 721**	11 727	87 829
Area in %	51%	**36%**	13%	100%

Source : CRRA, INRA-Rabat.

Table 3 : Soil texture of the Marchouch Experimental Estate.

Depth (cm)	Clay (%)	Silt (%)	Sand (%)	pH

0-20	50,0	37,3	12,7	7,8
20-40	51,3	38,2	10,5	8,2
40-90	52,5	35,1	12,4	8,6

Source : CRRA, INRA-Rabat

2.1.3. Agricultural production

Table 4: Area of Exploitations of Rommani Region in (ha)

Area in (ha)	Brachoua	Marchouch	Jemaa Moullabled	Total
0-5	39%	58%	64%	53%
5-10	23%	16%	19%	20%
10-20	18%	15%	9%	14%
20-50	9%	6%	5%	7%
>50	11%	4%	3%	6%
Number	1114	857	1075	3046
%	37%	28%	35%	100%

Source : Rommani Works Center, DPA Khemisset, DRA Rabat-Sale.

Table 5: Area of Major Agricultural Productions in the Region

(Average of 1995 to 2003) in (ha).	Ha	%
Cereals	244.550	66
Legumes	28.240	7.5
Fruit plantations	21.101	5.6
Vegetable growing	7.151	1.9
Forage crops	18.500	5
Industrial crops	2.420	0.6

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Tropical crops	2190	0.6

Source : DPA Khemisset 2004

Table 6: Yields Achieved for the Main Cultures of the Region in (Qx/ha)

Species	Averages yield in (Qx/ha)
Cereals	
Soft Wheat	11.11
Hard Wheat	9.8
Barley	9.6
Corn	6.5
Triticale	19.0
Legumes	
Bean	7.3
Pea	7.3
Lens	7.5
Chickpea	7.7
Haricot	7.1
Forage crops	
Oat	30
Fodder barley	14.7
Rye	28.7
Oats vetch	34.4
Lupine	33.6

Source : DPA Khemisset 2004

	Sept.	Oct.	Nov.	Déc.	Janv.	Fév.	Mars	Avril	Mai	Juin	Juil.	Aout	Durée cycle de culture
Blé dur													220 jours
Blé tendre													200 jours
Maïs													120 jours
Orge													180 jours

Céréales

	Sept.	Oct.	Nov.	Déc.	Janv.	Fév.	Mars	Avril	Mai	Juin	Juil.	Aout	Durée cycle de culture
Arachide													180 jours
Betterave													180-200 jours
Soja													150-180 jours
Sésame													150-180 jours

Oléagineux

Période de semis
Période de croissance
Période de récolte
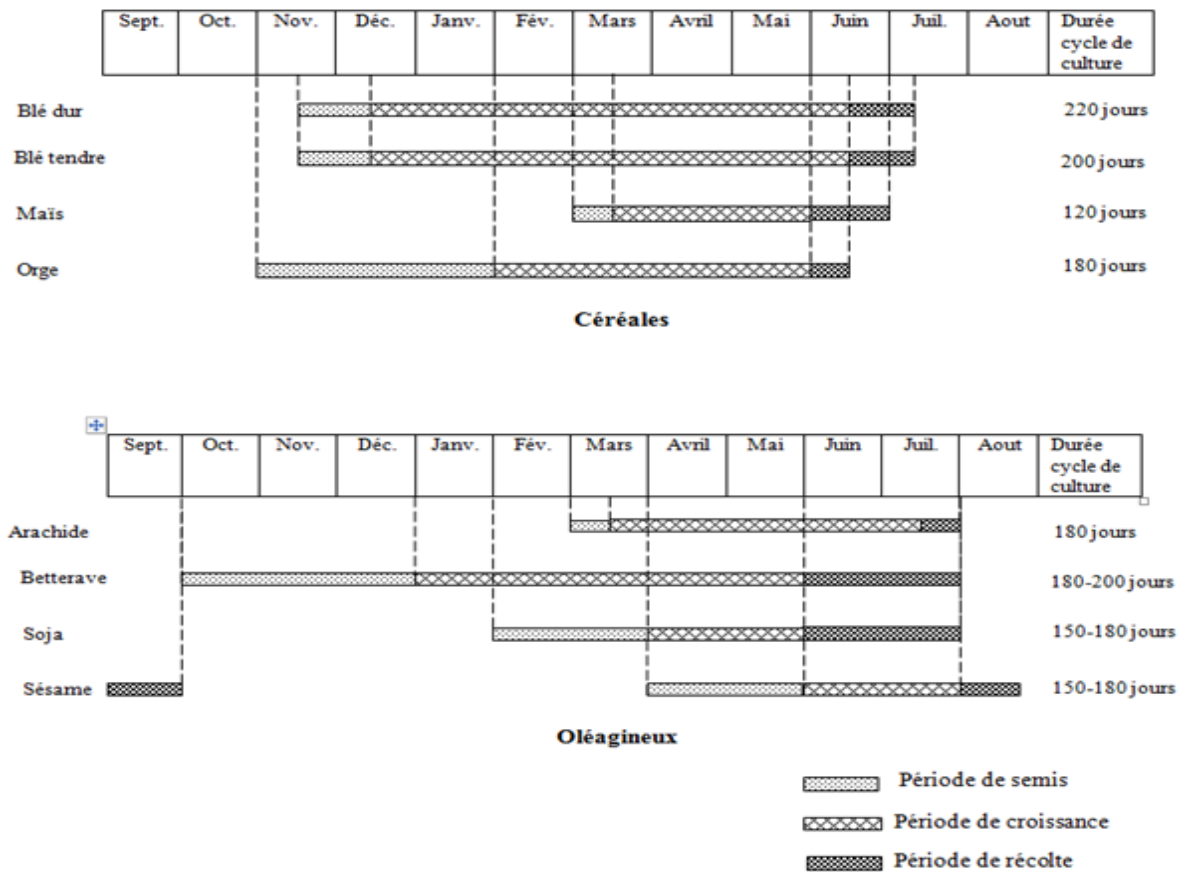
Figure 6: Cultural Calendar of the Bouregreg Watershed
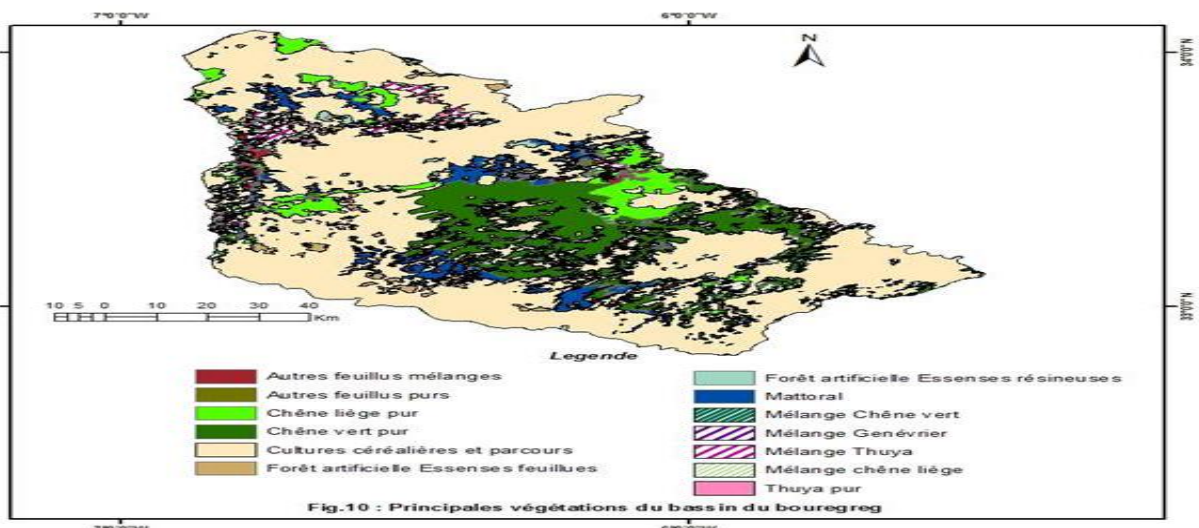
Figure 7: Main vegetation of the Bouregreg Basin (Source: CERGEO)

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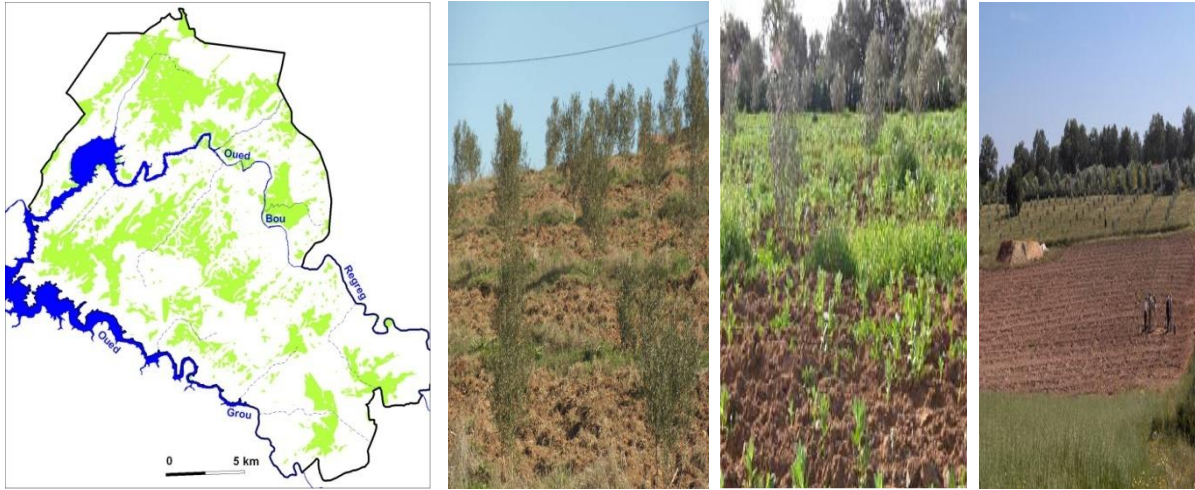
Figure 8: Agriculture on Balanced Land (Favorable Land) - Diversification and Irrigation -

2.1.4. Climatology

Figure 9: Classical Climatological Station Type (Source: SEE)

Figure 10 : Automated Weather Observing Station Type (Source: DMN)
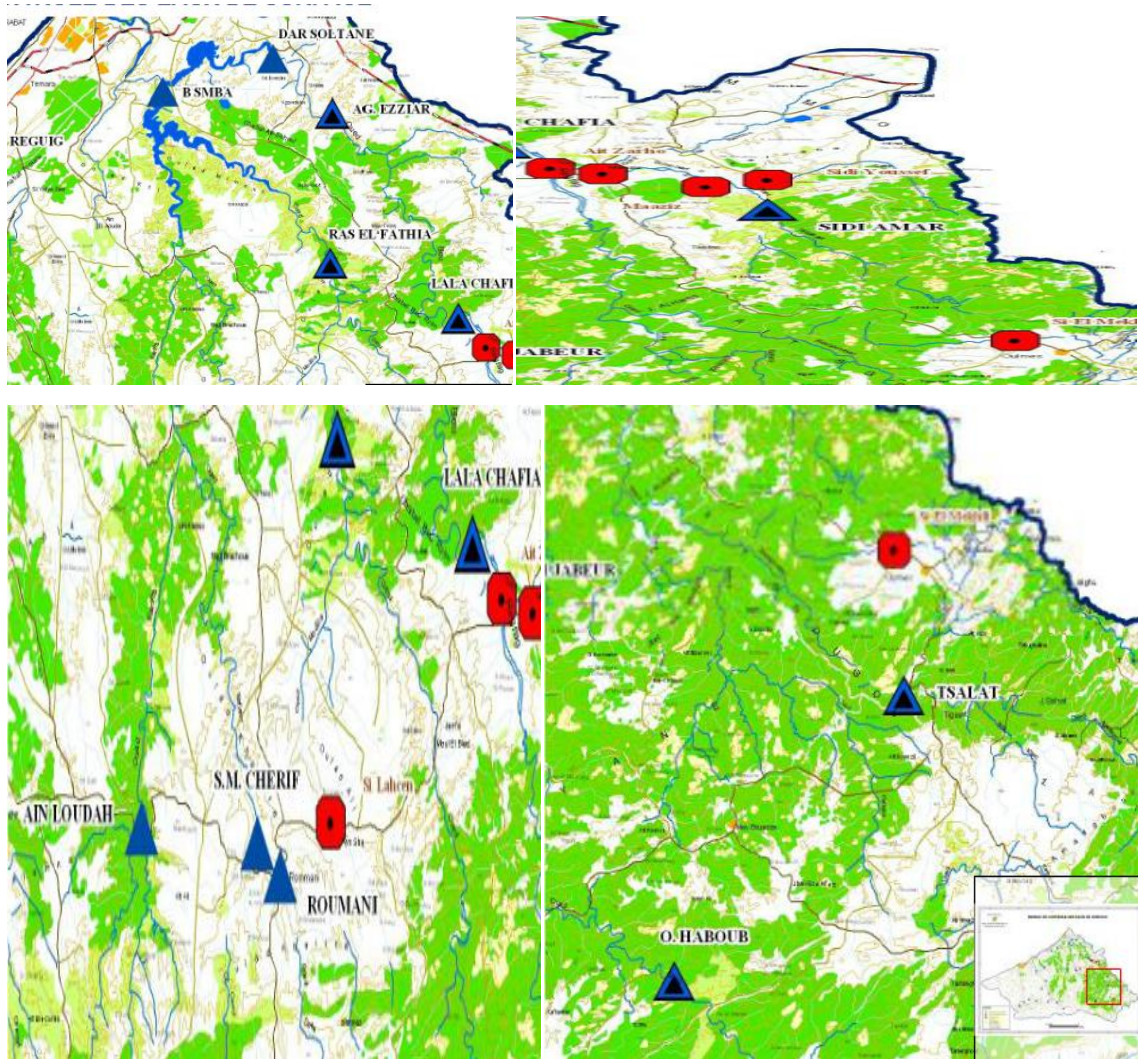
Figure 11: Main hydrometric stations in the Bouregreg basin (Based on the map of the ABHBC)
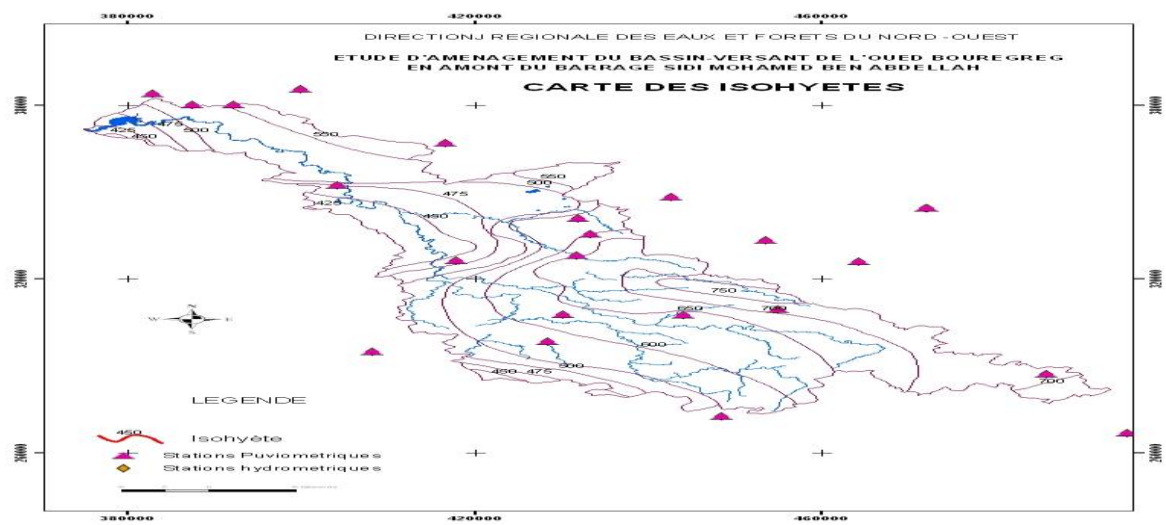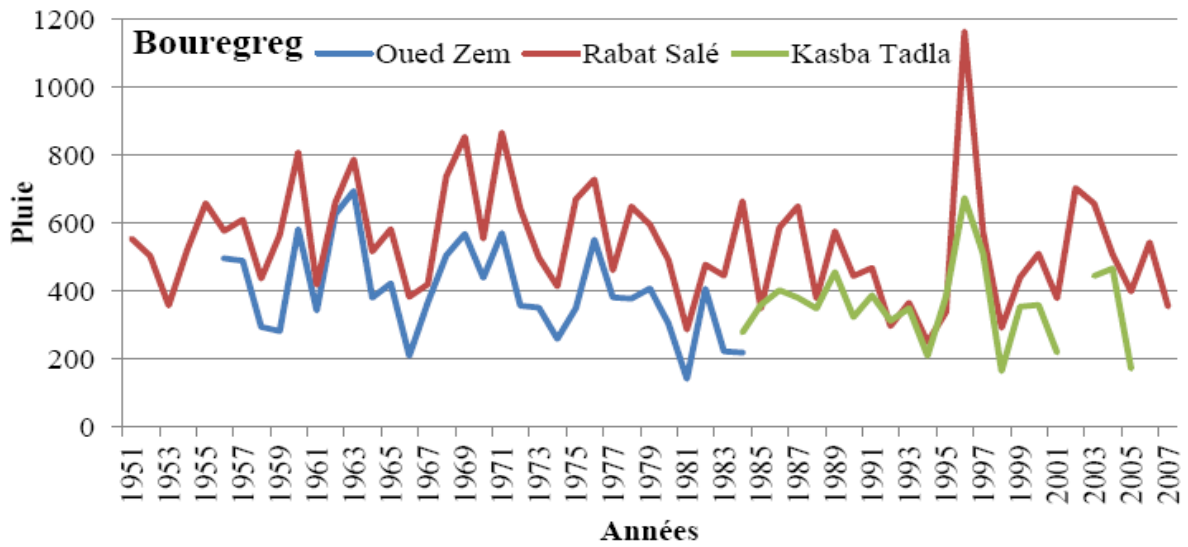

Figure 12 : Map of Isohyets.

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Figure 13: Evolution of the rainfall Series in the Bouregreg Basin (in mm)

Ombro-thermic diagram

According to the Bagnouls and Gaussen ombro-thermic diagrams of the stations for which data are available, it turns out that the dry period corresponds to the months of June to September for all stations as shown in(Figures 14 and 15).
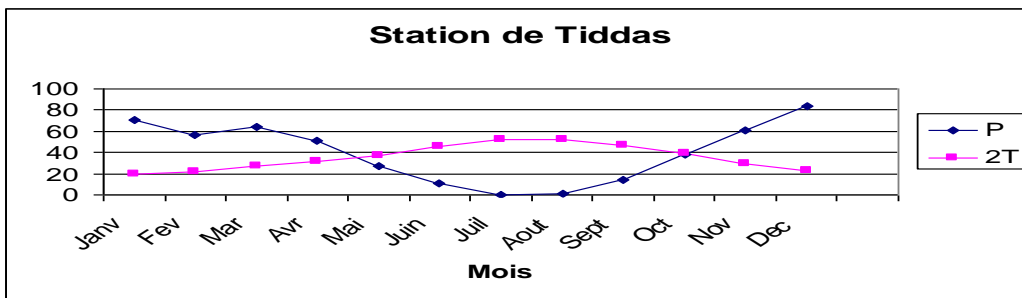
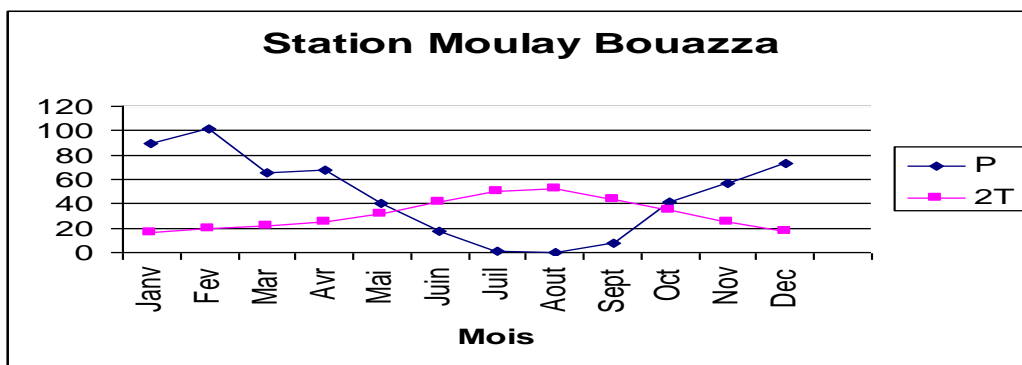**Figure 14: Ombro-thermic curve of the Tiddas station.**

Figure 15: Ombro-thermic curve of the Moulay Bouazza station.

2.1.5. Phenology

Table 7: Calendar of Cereal Growth Cycle Stages in Marchouch (INRA)

Observation dates	Seedling	Lifting	Tillering	Montaison	Heading	Flowering	Maturity
12 November	x						
22 November		x					
10 January			x				
15 Febrary				x			
25 March					x		
30 March						x	
25 May							x

Figure 16: State of the Marchouch Soft Wheat in March (Source: CRRA, INRA-Rabat)

Figure 17: State of the Marchouch Soft Wheat in April (Source: CRRA, INRA-Rabat)

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Finally, for projections of future returns according to climate change models, I used the future monthly climate parameters (Tmax, Tmin, Rain) for the year 2030 with scenario B2 and model HadCM3 (Hadley Center Model 3, British Meteorological Service) of *www.worldclim.org/futurdown.htm* and retrieve them by ArcGis software for visualization and display, then compare them with the current monthly climate data of the year (2007-2008) for the Marchouch experimental site, INRA.

The modeling adopted in this study is the "Crop-Syst" model that approaches the problem of agricultural production in a progressive manner. Three hierarchical levels are identified: potential growth, growth under water stress or nutritional stress (lack of fertilizers) and reduced growth (attack by parasites).

If the intake of water or nutrients below optimal during a phase or the entire growth period, this will lead to limited production due to lack of water or fertilizers.

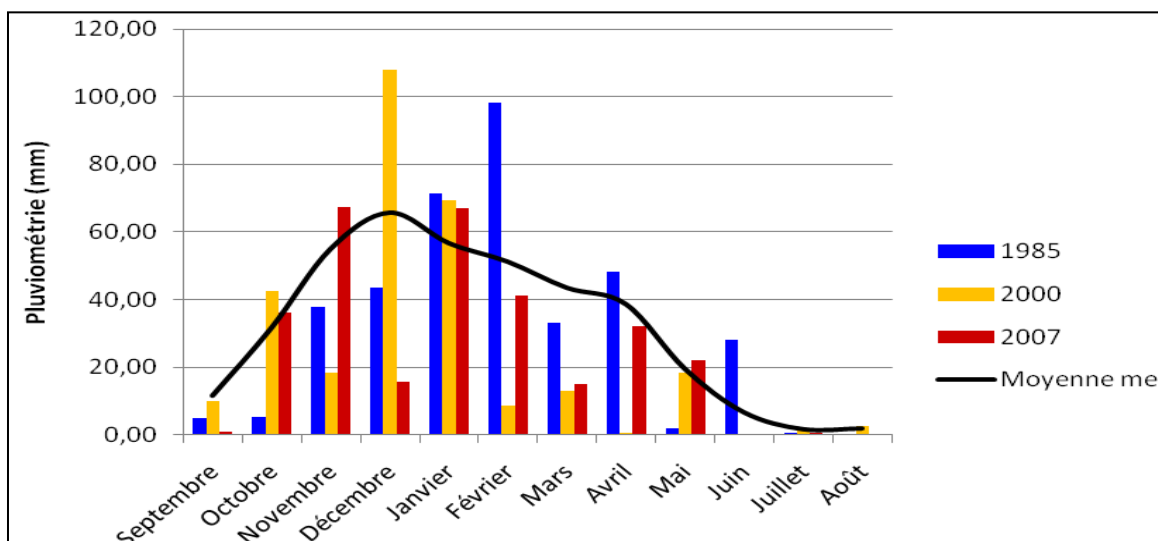**Climatic factor related to rainfall / water requirements of cereals**

Figure 18: Average monthly rainfall at the Bouregreg watershed scale in 1985, 2000, 2007

-Vulnerability related to the variability of plant productivity in relation to climate variability.

Mois	Jn	Jn	Jn	Jt	Jt	Jt	At	At	At	S	S	S	O	O	O	N	N	N	D	D	D	Nb jours
Décades	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
1999																						130
2000																						130
2001																						190
2002																						130
2003																						90
2004																						100
2005																						160
2006																						140
2007																						150
2008																						100
2009																						60

Figure 19: Variability of early and late seasons with low vegetation cover (NDVI <0.2) in cereal growing zone
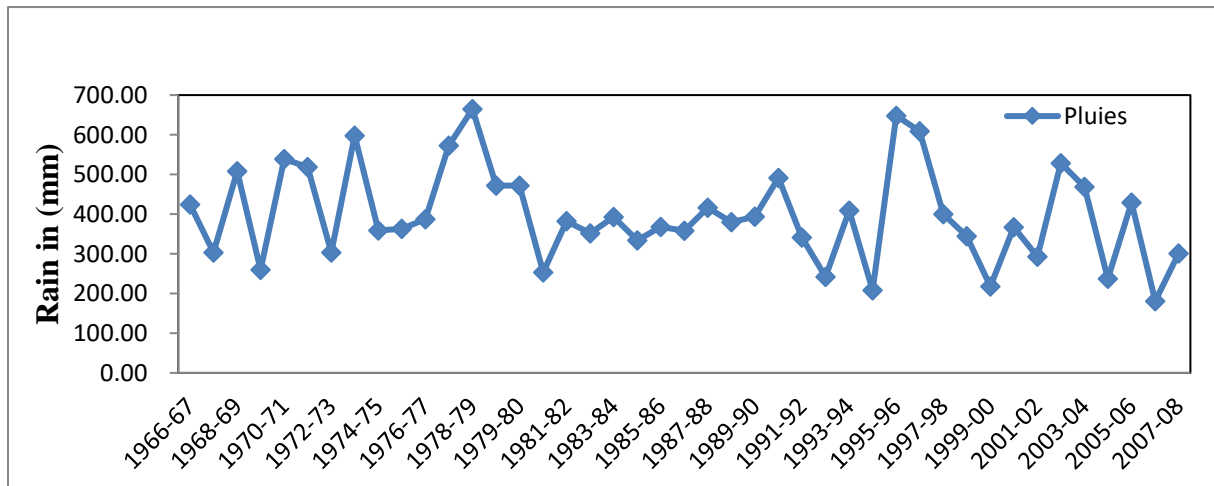
3. Results and Discussion

Figure 20: Rainfall evolution at Marchouch (INRA), from the period (1966-67 to 2007-2008)

The analysis of the climatic components gives us for the regime of precipitations, an irregularity of the inter-annual rains, in the period 1966/67 to 2007/08 with a peak of 664.50 mm recorded in campaign 1978/1979 and a minimum of 181.10 mm recorded in the 2006/2007 campaign.

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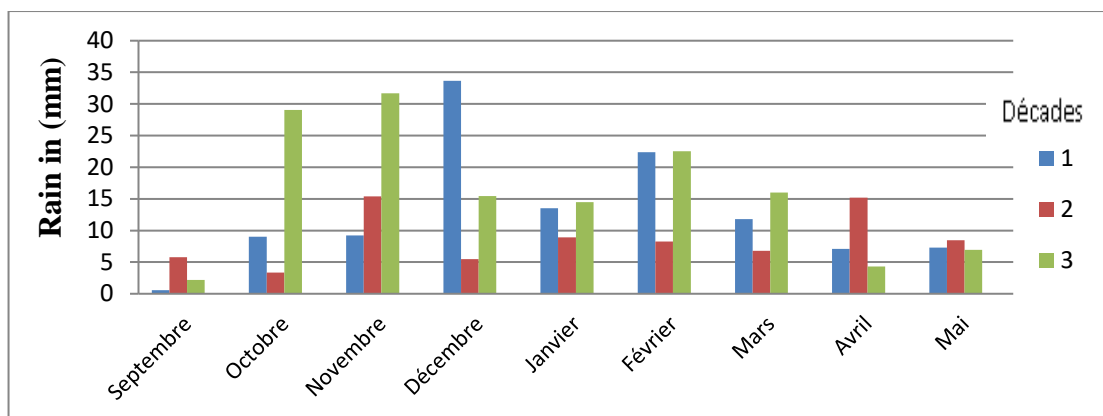
Figure 21: Decadal Variability of Rains during the Wheat Growth Cycle for the period (2003 to 2009)
corresponding to the date of sowing (2nd Decade of November) on the Maturation date (3rd
Decade of May) during the Cycle of Growth of wheat in Marchouch (INRA).

This figure illustrates the distribution of the irregularity of the ten-day rains during the wheat growth cycle for the period (2003 to 2009) in Marchouch. Between the months of September and December there is a cumulative increase in the 10-day rainfall, which is important for the early stages of the growth cycle, between December and January a fall in cumulative rainfall that corresponds to the cold phase of the cycle, while in February the rains increase again which is important for the supply of the water reserve because it is the critical stage of the plant growth where the plant needs a lot of water. From the month of March the decadal rains decrease until the end of the cycle. It is the phase of the flowering until the maturity or the degree-days of the temperatures are more important.
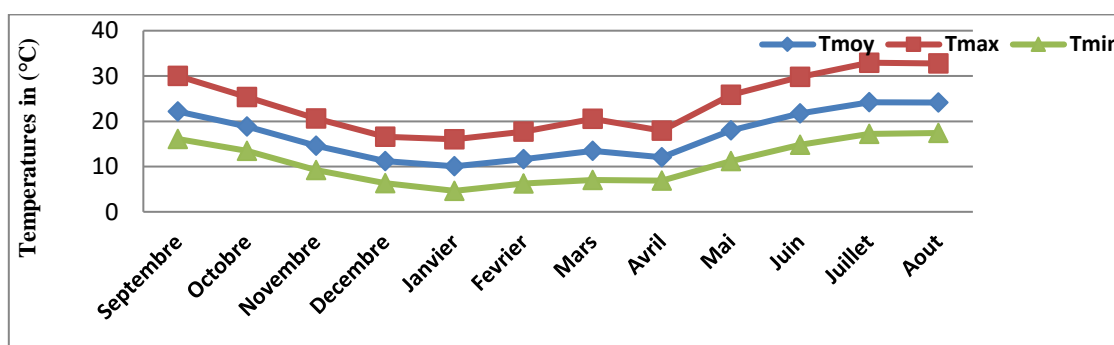
Figure 22: Evolution of Average Monthly Temperatures (Tmoy, Tmax and Tmin)
the Agricultural Campaign for the period (2003 to 2008), in Marchouch (INRA)

For the temperature regime, there is a change in the irregularity of the monthly average temperatures (Taverage Tmax and Tmin) between the months of the crop year for the period 2003 to 2008.
With a high of 32.93 (°C) recorded in July, a low of 04.63 (°C) recorded in the month of January.
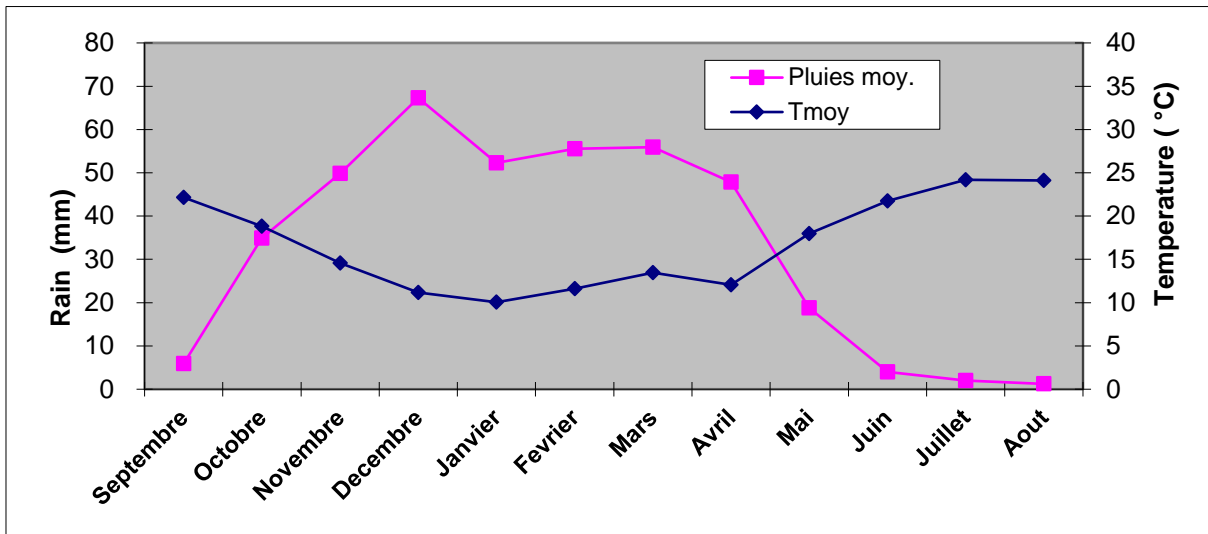
Figure 23: Ombro-thermic diagram of the Marchouch Experimental Domain (INRA)

An ombro-thermic diagram that tells us about the wet and dry periods during the growing season (September -August) and the period of plant growth for the series from 2002/2003 to 2007/2008.
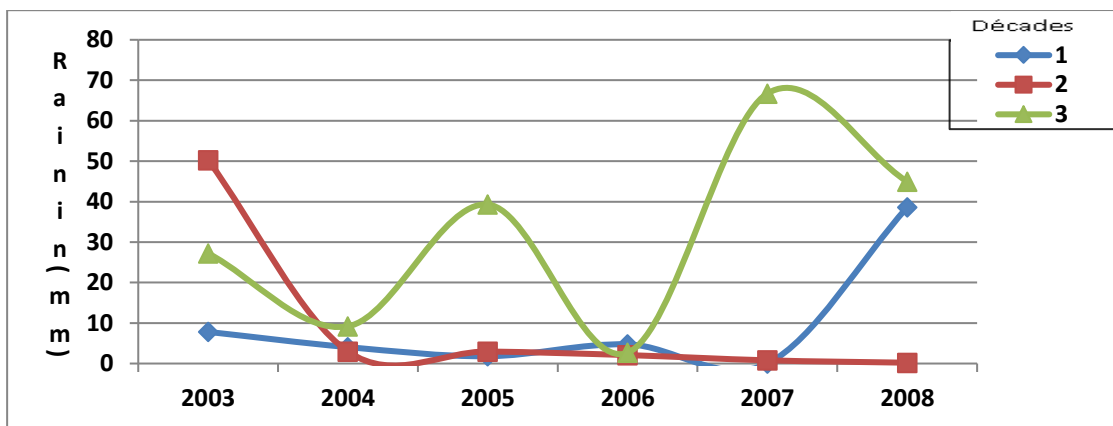

Figure 24: Evolution of the three decades of the month of November at the Experimental Domain Marchouch, INRA

The analysis of the growth and production of wheat by an agro-climatic characterization using the dates of sowing and water deficit, shows the temporal evolution of the accumulations of rains of the 3 decads of November for the period 2003 to 2008. It allows us to choose the optimal date of early sowing, which allows us to use the accumulated first rains fallen, in order to satisfy the useful reserve of the water needs for the plant during the emergence phase.

El Houssaine OUHARBA[a*], Zine el abidine TRIQUI[a], Rachid MOUSSADEK[b]
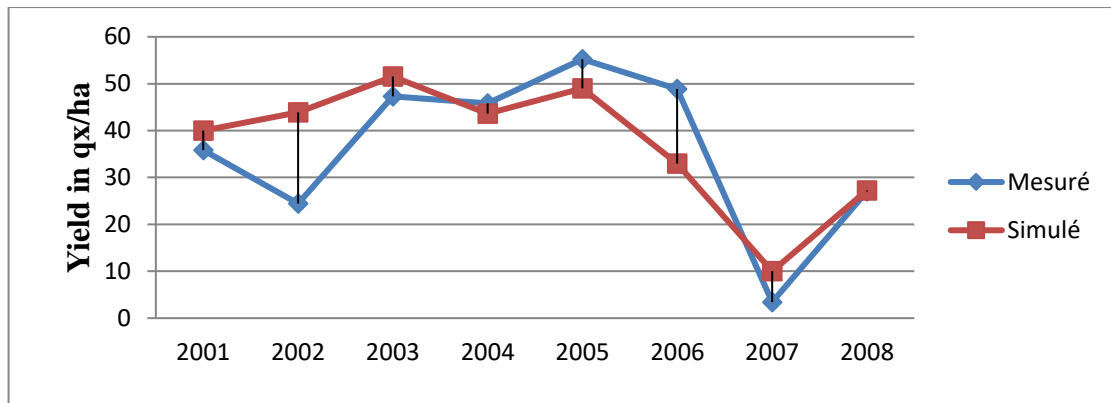
Figure 25: Comparison between measured and simulated yield at the Experimental Domain Marchouch, INRA.

The analysis of yields shows the irregularity of average yields of soft wheat from the 2000/01 to 2008/09 crop years. Yields are marked by a peak of 55.24 qx / ha measured in the 2004/05 season and a minimum of 3.42 qx / ha measured during the 2006/07 season.
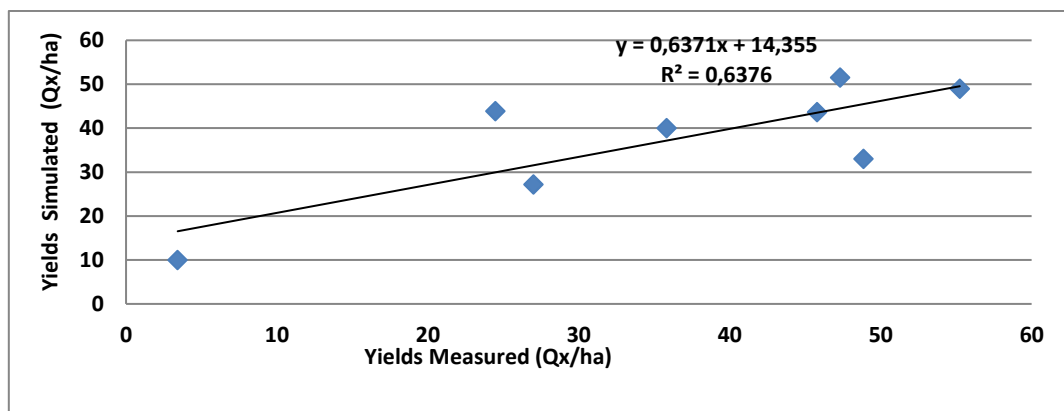
Figure 26: Relationship between measured and simulated yields in Marchouch

The simulation of yields by the Crop-Syst model (Stöckle, Nelson, 2005) and comparison between measured and simulated yields at Marchouch (Rommani), gives a significant correlation between the measured and simulated yields of ($R^2 = 0.6376$).

Taking into account the calibration of the model on the study site which remains estimated in relation to the real characteristics of the environment and crops.

Simulation of Returns by the CropSyst Model (Stöckle, Nelson, 2005)

3.1. Simulation outputs
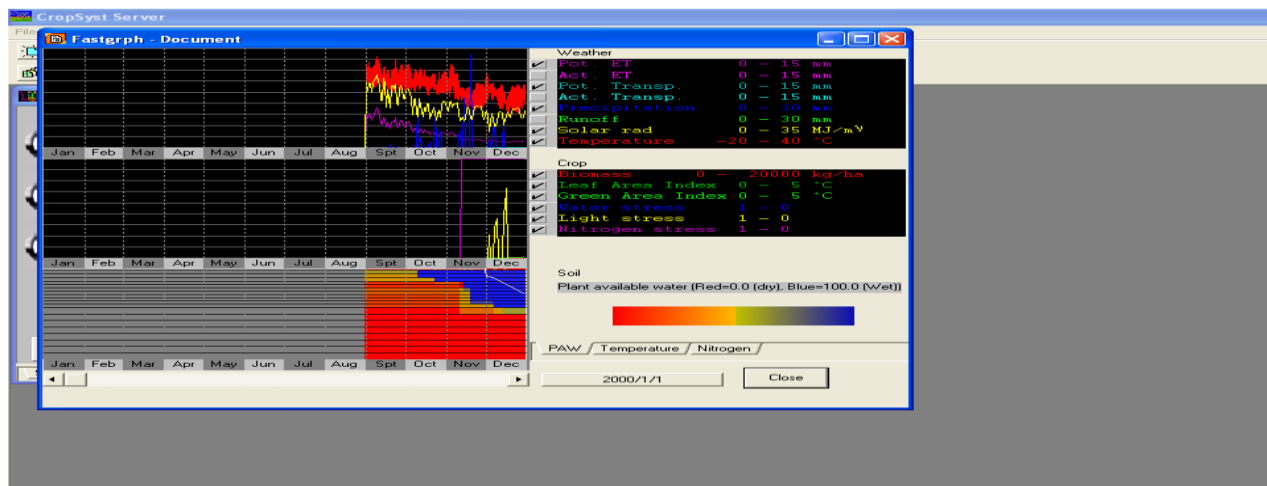
Fastgraph document

Table 8 : Simulated Harvest Report.

seedling	Emergence	Flowerisg	Maturation	Maturity	Harvest	Emergence	Actual ETP (mm)	Yield (Qx/ha)	Yield (Qx/ha)	Rain (mm)
								Simulated	*Measured*	
12/11/2000	30/11/2000	28/04/2001	13/05/2001	26/05/2001	11/06/2001	333,2000	171,16	40.00	35.82	161,60
13/11/2001	27/11/2001	28/04/2002	11/05/2002	23/05/2002	08/06/2002	331,2001	309,03	43.89	24.46	362,20
13/11/2002	27/11/2002	02/05/2003	14/05/2003	25/05/2003	10/06/2003	331,2002	308,62	51.51	47.32	457,20
13/11/2003	27/11/2003	05/05/2004	18/05/2004	31/05/2004	16/06/2004	331,2003	276,23	43.65	45.78	437,50
12/11/2004	27/11/2004	03/05/2005	13/05/2005	25/05/2005	10/06/2005	332,2004	167,74	49.00	55.24	168,70
13/11/2005	27/11/2005	03/05/2006	14/05/2006	25/05/2006	10/06/2006	331,2005	211,18	33.00	48.86	268,40
13/11/2006	25/11/2006	05/05/2007	16/05/2007	29/05/2007	14/06/2007	329,2006	237,31	10.00	3.42	188,20
13/11/2007	25/11/2007	26/04/2008	07/05/2008	22/05/2008	07/06/2008	329,2007	156,66	27.21	27.00	158,40

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Projection of future returns according to climate change models using in this work scenario B2 to compare between the current maximum temperatures of the campaign (2008-09) and future of the year (2030), the current minimum temperatures of the campaign (2008-09) and future of the year (2030) and the current rains of the campaign (2007-08) and future of the year (2030) of the Experimental Domain Marchouch, INRA.
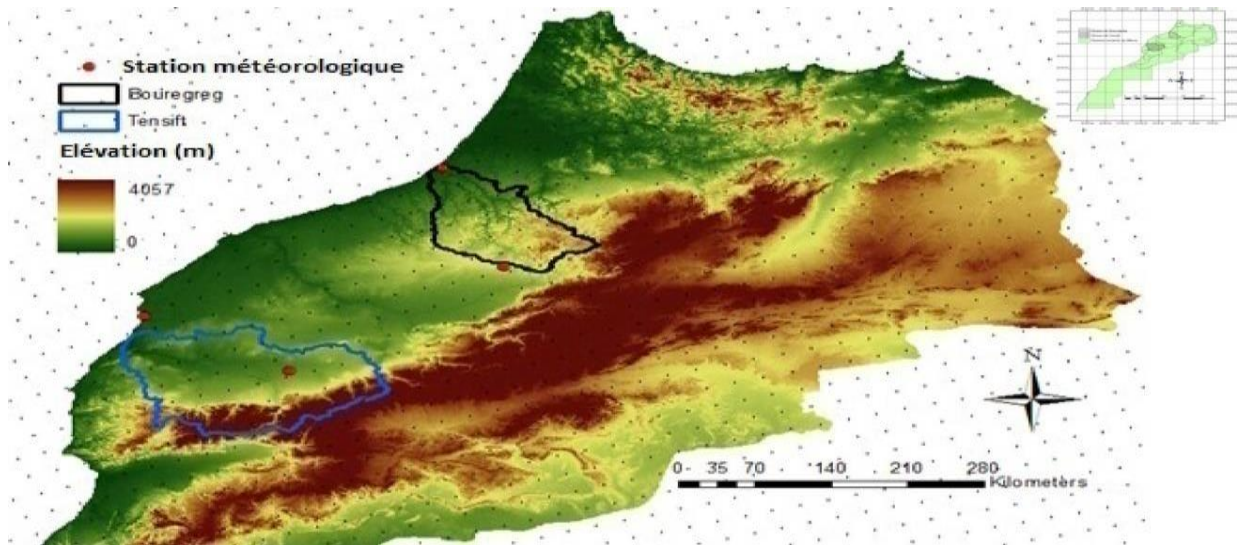

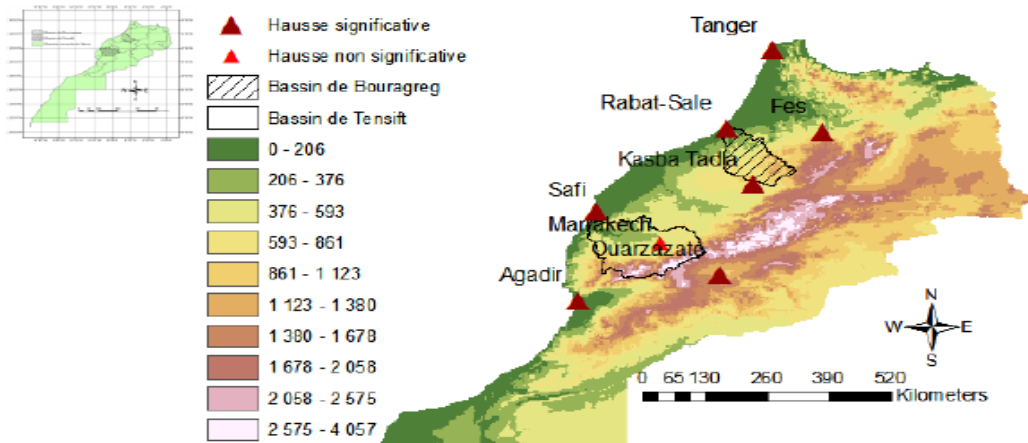**Figure 27: Grid of regional climate models (Black dots).**

Figure V. 7 : Tendance des températures dans la zone d'étude

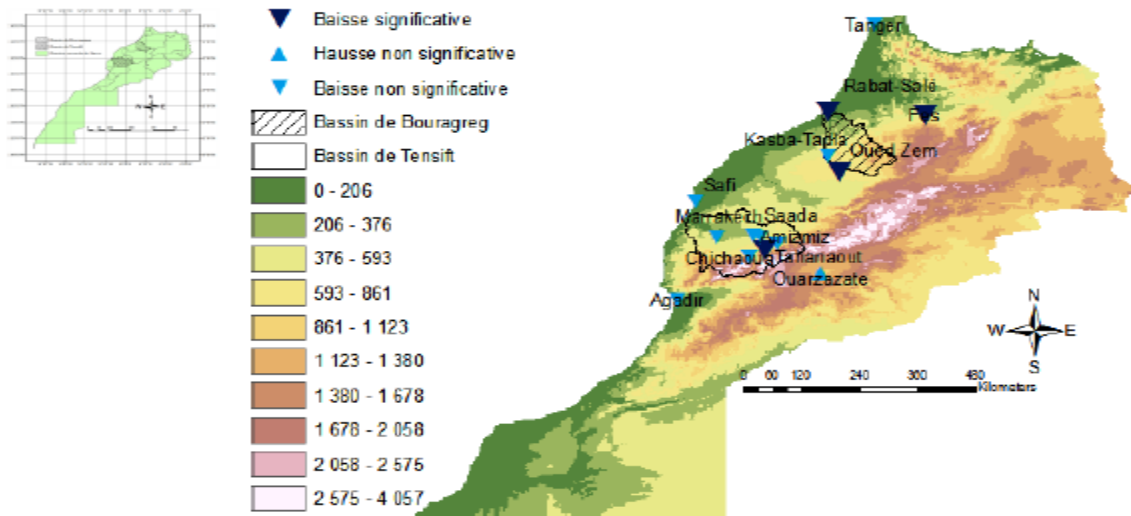**Figure 28: Temperature projection in the study area**

Figure V. 8 : Tendance des pluies dans la zone d'étude

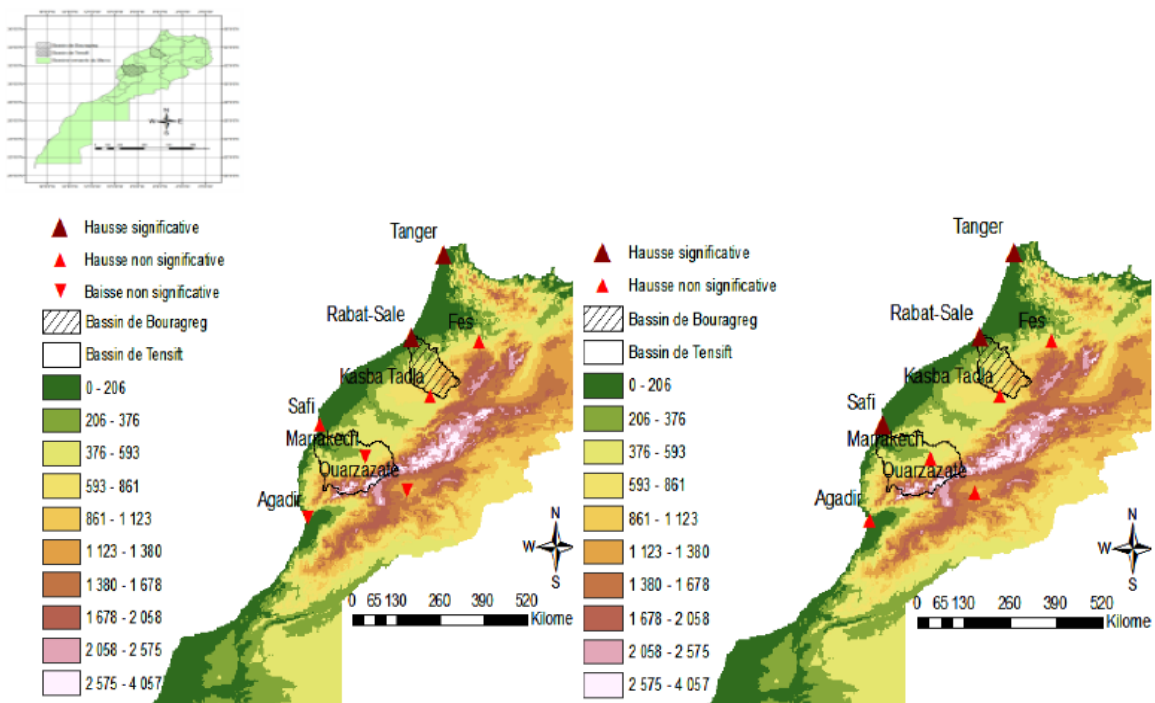**Figure 29: Rainfall projection in the study area**

Figure VI.4 : Tendance des températures maximales dans les sites d'étude en été (gauche) et en hiver (droite)

Figure 30: Projection of maximum temperatures in study sites in summer (left) and in winter (right)

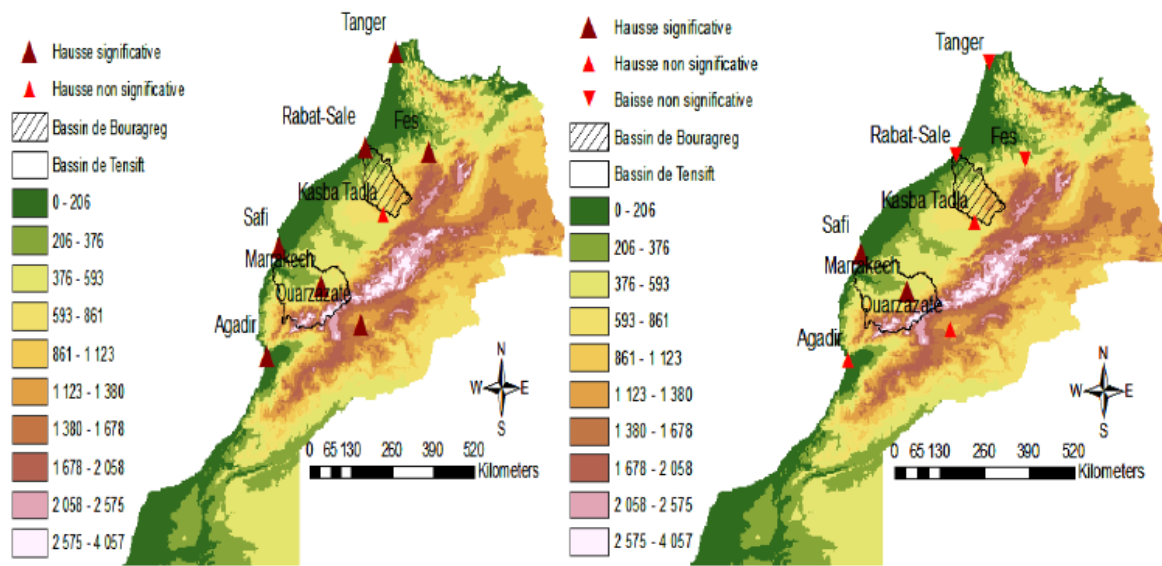El Houssaine OUHARBA[a*], Zine el abidine TRIQUI[a] , Rachid MOUSSADEK[b]

Figure VI.5 : Tendance des températures minimales dans les sites d'étude en été (gauche) et en hiver (droite)

Figure 31: Projection of minimum temperatures in study sites in summer (left) and in winter (right)

Tableau 9: Comparison between the current maximum temperatures of the season (2008 - 09) and future of the year (2030) of Exp. Marchouch, INRA

	Present	Future
	2008-2009	2030
Months	T max	T max
September	28,22	28,40
October	22,44	22,80
November	17,67	16,30
December	15,25	13,10
January	14,33	15,30
Febrary	17,54	17,10
March	20,59	19,40
April	20,26	20,50
May	26,26	26,90
June	30,86	30,70
July	29,22	34,60
August	31,44	33,50
Average/year	22,84	23,22

Tableau 10: Comparison between the current minimum temperatures of the campaign (2008 - 09) and future of the year (2030) of Exp. Marchouch, INRA

|	Present	Future
	2008-2009	2030
Months	T min	T min
September	15,70	16,60
October	12,10	13,30
November	7,60	9,50
December	6,40	6,80
January	5,90	5,20
Febrary	7,40	6,20
March	9,80	7,40
April	7,00	9,30
May	11,70	12,30
June	16,10	15,90
July	15,40	17,60
August	16,20	17,90
Average/year	10,94	11,50

Tableau 11: Comparison between the current rains of the season (2007-08) and the future of the year (2030) of the Marchouch Experimental Domain, INRA.

	Present	Future
Months	Rain	Rain
	2007-2008	2030
September	1,40	7
October	15,94	10
November	67,52	17
December	14,85	8
January	52,87	2
Febrary	45,44	2
March	13,07	3
April	44,74	2
May	45,25	2

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June	0,00	0
July	0,00	1
August	0,00	3
Cumulative/year	301	57

For the rains, according to the B2 model proposed for the study area, it turns out that in the future there will be less rainfall (about less than 80%). It is a strong aridity that will settle in the region of the Marchouch Experimental Domain, INRA, according to the climate scenario.

For temperatures (T max and T min), according to the climate scenario model B2, there will be a temperature increase of approximately (+1 to 2°C). The study area will become hotter in the future. For future yields under scenario B2, the study area will become more arid in the future which will have direct and negative effects on cereal yields. This is in line with the results obtained in the WB/ FAO / INRA / DMN report prepared by the World Bank Morocco study (Gommes et al., 2009).
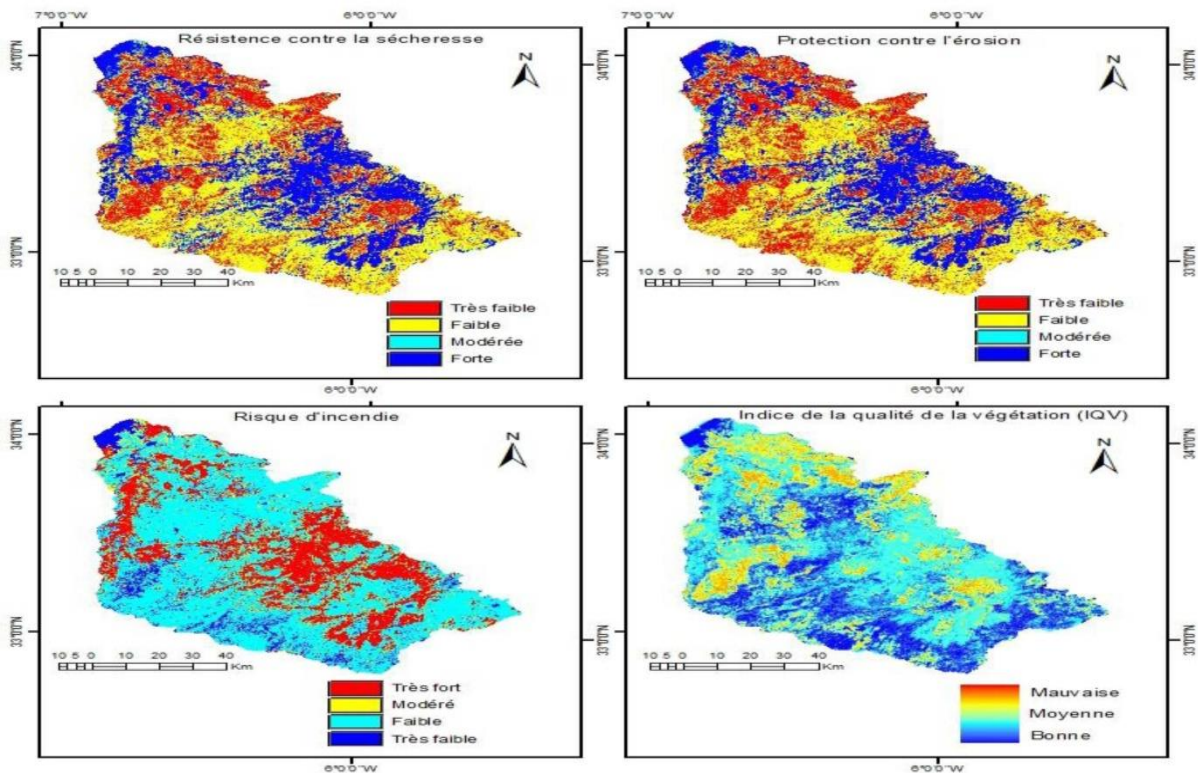
Figure 32: Characterization of the quality of the vegetation.

Critical areas in terms of degradation are 2% of the basin. Thus, more than a quarter of the basin is a fragile space in terms of agricultural and pastoral exploitation. The 1975 study by the FAO on the state of the environment (REEM, 1999) already indicated that 54% of the Bouregreg basin should not be cultivated because of their fragility. At the spatial level (Figure 32), the spaces where the degradation represents a critical risk are located in the southern part of the basin (upstream).
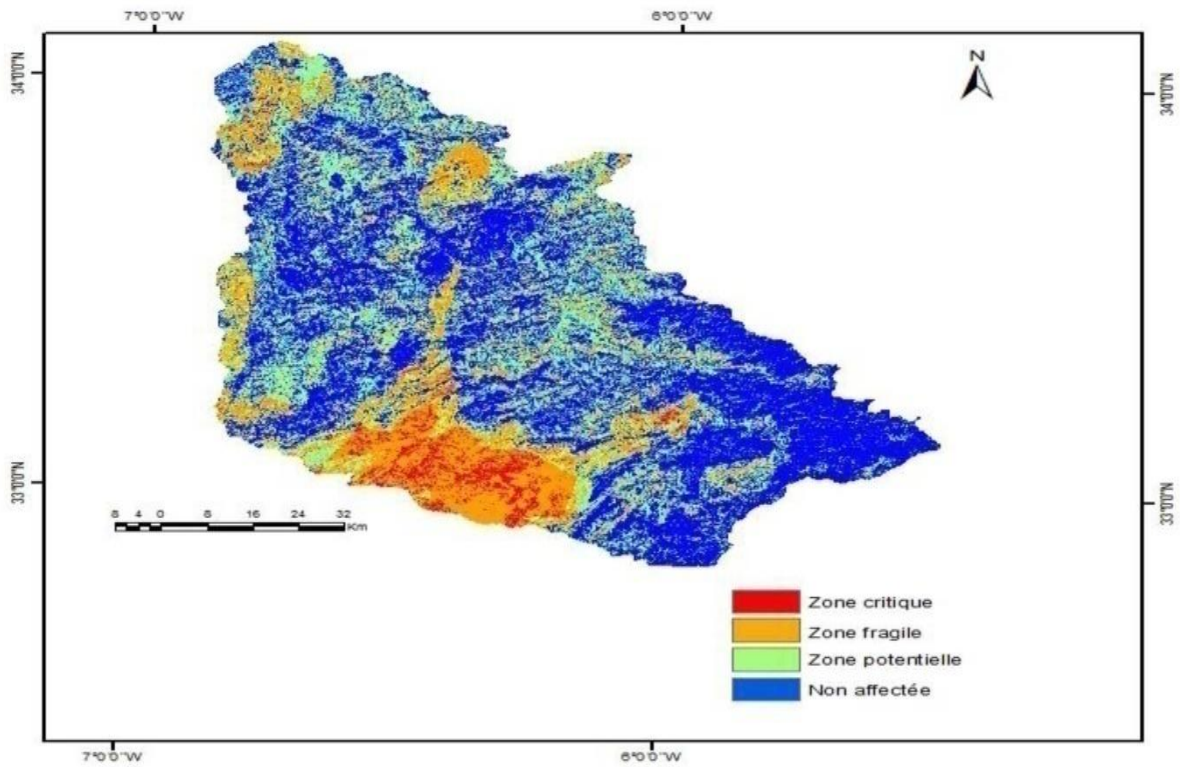
Figure 33: Map of the risk of soil degradation in the Bouregreg watershed.

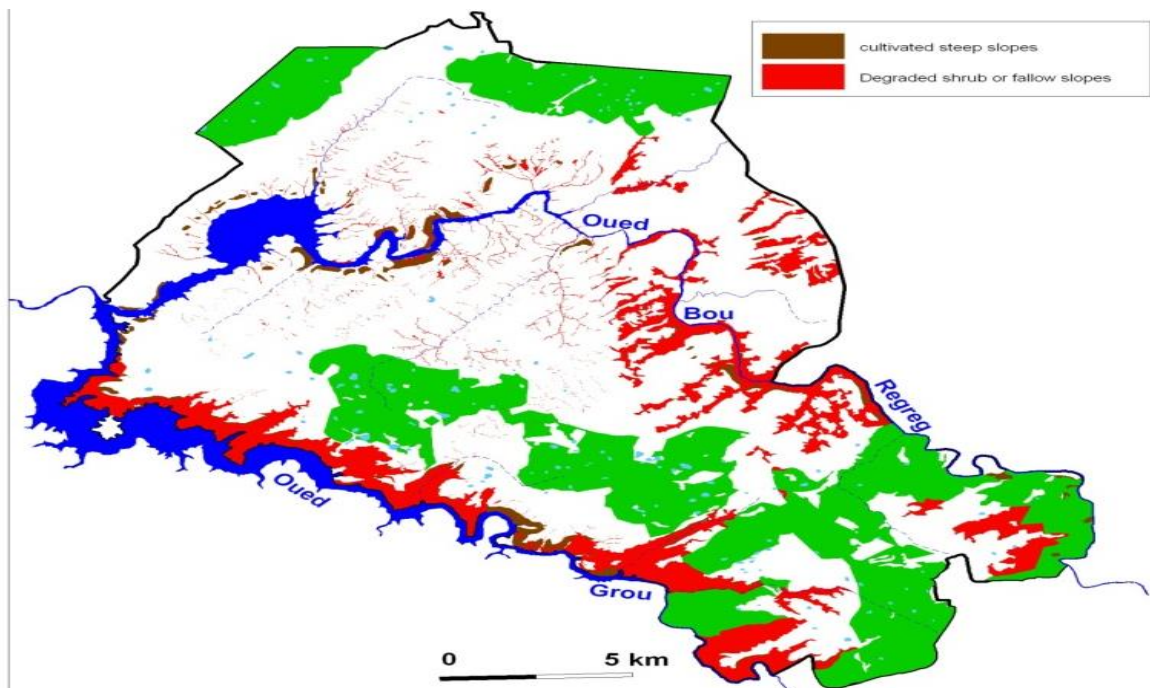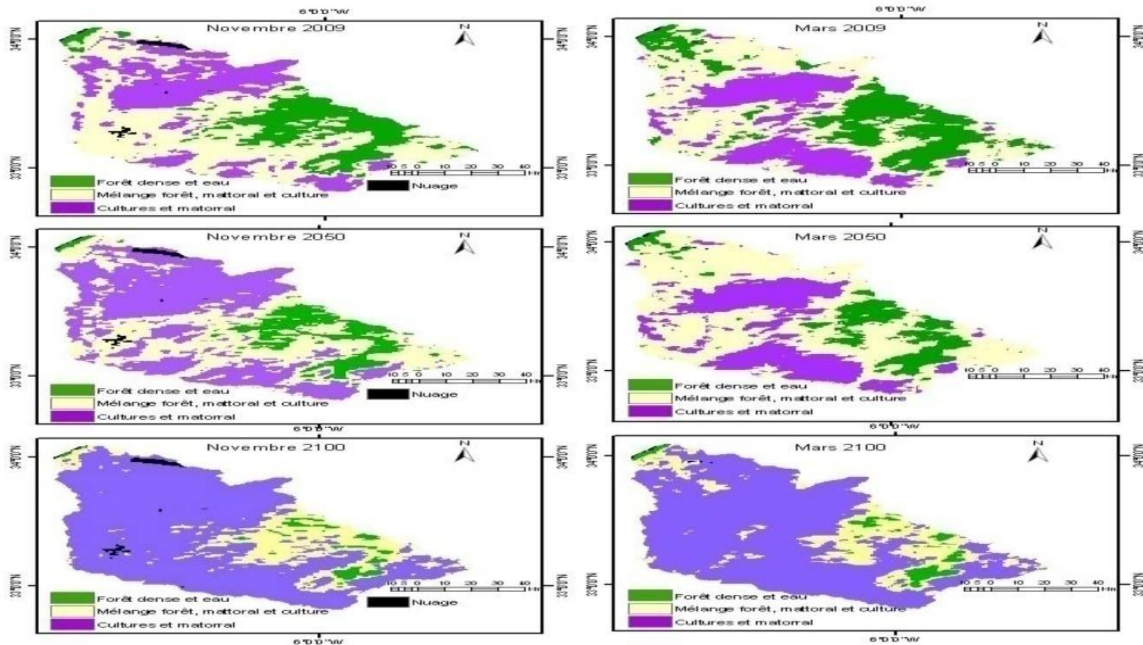**Figure 34: Dynamics of the courses (The 3 types of course: - Forests, -Matorral degraded, -Degraded and abandoned cultivated land.**

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Rainfed agriculture will disappear

Figure 35: Evolution of the vegetation determined from the surface temperatures of the MODIS images and MCR-CNRM.

4. Conclusion

This work examines climatic hazards that cause significant fluctuations in agricultural production in the Rommani region, which results in a comparison and correlation between yields and meteorological parameters thus giving significant dependence between the two.

A modeling approach by Crop-Syst was used to obtain estimated returns and compare them to measured returns.

In order to better understand this problem throughout the Bouregreg basin, it would be wise to follow very closely in space and time. And this, by a study of comparison of the studied region with the different regions of the Basin, with an application of the models of simulation of agriculture. Adopting modeling will undoubtedly help decision-makers alert farmers to the risks of agricultural drought and to forecast wheat import requirements in advance, thus helping the country's food security and also; to estimate the impact of climate change on wheat productivity in the Rommani-region.

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