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Drought and climate change in Morocco. Analysis of precipitation field and water supply

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SUMMARY – The studies made by the Moroccan Meteorological Office (La Direction de la Météorologie Nationale) have shown obvious changes in the climate the country has undergone in recent decades including the phenomenon of drought. The thirty year period 1971-2000 registered a decline of about 15% in the annual average of water supply. Since 1961, 1982-83, 1983-84 and 1994-95 were the hydrological years of most severe droughts that Morocco has experienced. The year 1994-95 has seen the minimum volume of precipitation water supply ranging from 38% in the north-west and south-west, to 80% in the south-east. The following year 1995-1996 has recorded the maximum value of such water supply since 1961, following the strong precipitation in the beginning of the rainy season. In addition, the inter-annual precipitation field experienced a trend of yearly decline, with a slight increase at the beginning of the season, and a decline afterward, especially in the spring. Drought is a plague that exists in Morocco since the beginning of the last century, with a cyclic temporal frequency of 11 years on average. Over the last three decades, the frequency, intensity and duration of drought have increased, and consequently, have led to an increase in their temporal persistence, especially in the spring.

Key words: Water supply, drought, topography.

RESUME – *"Sécheresse et changement climatique au Maroc. Analyse des précipitations et des apports en eau". Les études réalisées par la Direction de Météorologie Nationale ont mis en évidence les changements que le climat du pays a connus durant les dernières décennies, notamment le phénomène de la sécheresse. La période trentenaire 1971-2000 a enregistré une diminution des apports pluviométriques en eau annuelle moyenne de l'ordre de 15%. Depuis 1961, 1982-83, 1983-84 et 1994-95 étaient les années hydrologiques de sécheresses les plus sévères que le Maroc ait connues. La saison 1994-95 a enregistré le volume minimal des apports pluviométriques en eau variant de 38% au nord-ouest et au sud-ouest, à 80% au sud-est. L'année suivante 1995-96 a enregistré la valeur maximale de ces apports depuis 1961, suite aux très fortes précipitations du début de la saison. En outre, le régime pluviométrique inter-annuel connaît une tendance annuelle à la baisse, avec une légère augmentation des pluies de début de la saison et un déclin de celles du reste de la saison notamment au printemps. La sécheresse est un fléau qui existe au Maroc depuis le début du siècle dernier, sous forme cyclique d'une périodicité moyenne de 11 ans. Durant les trois dernières décennies, la fréquence, l'intensité et la durée de la sécheresse ont augmenté, entraînant en conséquence, une augmentation de leur persistance temporelle notamment au printemps.*

Mots-clés : *Apports en eau, sécheresse, topographie.*

Introduction

Morocco is located in the northwest of Africa between the parallels 20.5°N and 36°N. Its climate is marked by a sharp contrast warming (Mediterranean climate and desert). The topography is very accentuated, comprises two large mountain chains (Rif and Atlas) with a peak of 4165 m. This type of terrain induces a strong anisotropy of precipitation. In addition, the average annual precipitation varies from less than 100 mm in the south and south-east of the country to reach 1000 mm on the Middle Atlas and greatly exceed 1700 mm on the Rif mountains.

Morocco, for its oceanic and atmospheric characteristics and its geographical location in a region at risk of global changes, is not immune to changes in the various components of the climate system response to the radiative forcing altered by emissions of greenhouse gases. The findings show that Morocco has experienced over the past three decades several changes in the annual climate cycle. In particular, frequent droughts have occured in recent years as well as heavy precipitation situations. The Moroccan Meteorological Office has implemented several programs to address these national concerns by developping policies to prevent such extreme weather events. For this purpose, special

importance is given to actions in order to better understand the climate variability and the related water resources, in particular the estimatation of the current state of water: volume of water resources and their variability in the country, annual precipitation means and extremes of watersheds.

The approach is based on an analysis of the inter-annual variability in precipitation and the coupling between surface precipitation measurments and a numerical model of terrain (NMT) with a fine mesh, which would take into consideration the effects of soil and the precipitation data, since the topography is a dominant factor in precipitating process (Benichou and Le Breton, 1986; Laborde, 1995). The data used in the present study are for the surface over the climatological thirties of 1971-2000, available on the area of interest. The NMT has a resolution of 900 meters. The precipitation data interpolated on the grid of the NMT model, based on a multiple linear regression using combinations of the topography of each station as predictors. The regression residue is spatially interpolated by a kriging method using a different variogram per basin (the model-direction adjustement) (Hevesi *et al.*, 1992). Particular attention is devoted to the analysis of data to examine their quality, reliability and uniformity.

General trends of the precipitation

The principal component analysis (PCA) aims, among others, to establish the evolution of the average annual precipitation field. Figure 1 shows a significant change in precipitation since 1974 with an overall downward trend. Figure 2 gives the regionalization of the annual precipitation average, defining the areas associated with different precipitation patterns.

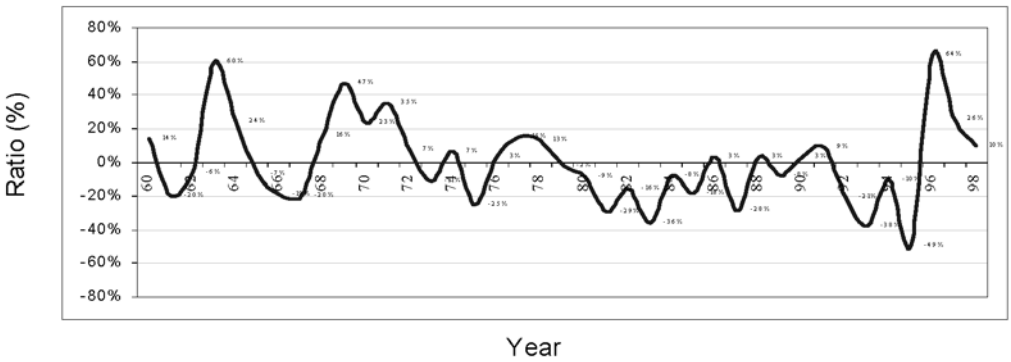

Fig. 1. Precipitation anomalies (%) over 1960-2000. The anomaly was defined as ratio of the annual totals to the climatological means.

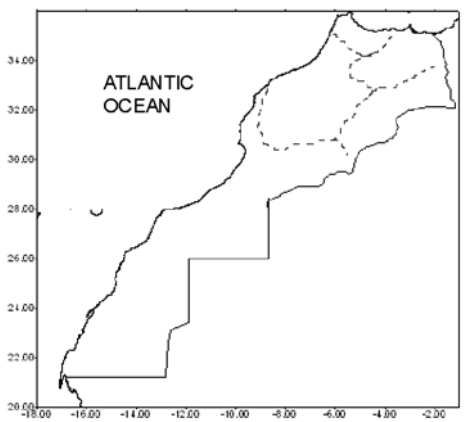

Fig. 2. Regionalization of the annual precipitation field for Morocco.

Changes in water supply

The average annual precipitation water supply, calculated, experienced a decrease of about 15% nationally during the period 1971-2000 compared with that of 1961-1990, which is defined by the WMO to be a period of reference of the normal climate. The volume of these precipitation water supply is of the order of 127 billion cubic meters for the period 1971-2000 whereas it was in the order of 150 billion cubic meters to that of 1961-1990 (the ground water potential availability was around 17 billion cubic metres). The hydrological years 1982-83, 1994-1995 and 1983-84 were years of the most severe drought that Morocco has experienced during this period between 1971 and 2000. The precipitation water supply of the basins, on those three years, recorded the minimum values of this 30 yr-period, with a reduction of between 38% to 80% from north to south, in relation to averages annual, which have been calculated for the period 1971-2000 (Fig. 3), and have suffered a decline on south of the country (basins on the right of the x-axis in Fig. 3), less important than those of the north.

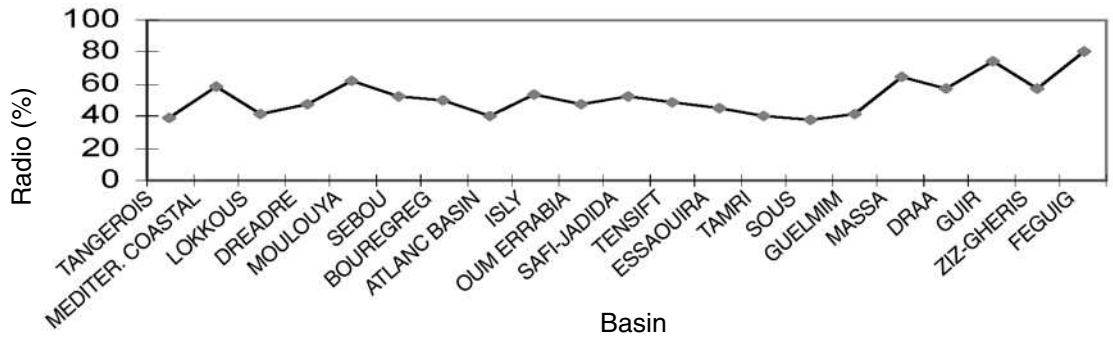

Fig. 3. Ratio of the minimum precipitation water supply for the period 1971-2000 to annual means for the same period (%).

Drought analysis

The study of climate change-related droughts, based on the indices defined as deciles and ratios between the annual precipitation totals and the climatological values of the 1961-90 period, shows the existence of inter-annual variability of drought in time and space. In fact, the analysis made on the variability of precipitation since 1886 showed the existence of drought since the beginning of the last century and has highlighted the presence of a cycle of drought in Morocco with an average periodicity of 11 years. Moreover, the frequency of periods, the intensity and duration of drought have increased over the past three decades (Fig. 4) and consequently led to an increase in their temporal persistence especially in the spring.

The inter-annual precipitation regime has recorded a slight increase rainy season in the beginning and a decline in the rest of the season especially in the spring. This decline is around 25% for the aggregate precipitation of the rainy season in the north-west of the country. The precipitation of spring are showing downward trends in the range of about 45% nationally (Fig. 4), and those of the winter show downward trendsm but not statistically significant especially in the inland areas.

Regarding the extreme events, the beginning and the middle of the rainy season show an increase due to very heavy precipitation. The analysis of annual precipitation shows upward trends in these events in the basins of the extreme north and southwest. The beginning of the 1995-96 season has seen the maximum values including record precipitation in the northwest and west as shown in Fig. 1.

The analysis of average annual temperatures on Morocco showed a significant increase of about 0.16°C per decade.

year	NORTH OUEST	NORTH EST	ATLANTIC PLAINS	SOUTH OUEST	SOUTH EST
1976	0,83	1,08	0,87	0,74	0,94
1977	1,68	1,18	1,14	1,12	1,05
1978	1,1	1,09	1,05	0,89	0,01
1979	1,08	0,89	1,07	0,87	1,12
1980	0,77	0,93	0,72	1,11	1,12
1981	0,64	0,72	0,54	0,52	0,87
1982	0,66	0,93	0,64	1,43	0,87
1983	0,72	0,79	0,62	0,75	0,37
1984	1,12	0,84	0,74	0,64	0,27
1985	0,84	0,69	0,83	0,81	1,3
1986	1,02	1,04	1,04	0,78	0,45
1987	0,79	0,74	0,68	1,71	1,23
1988	0,98	0,94	1,15	1,54	2,14
1989	0,86	0,8	0,74	1,29	2,53
1990	1,03	1,14	0,93	0,72	1,04
1991	1,12	1,14	1,15	0,78	1,22
1992	0,81	0,99	0,67	0,17	1,55
1993	0,85	0,36	0,36	0,83	1,02
1994	0,01	0,74	0,97	0,29	0,75
1995	0,48	0,44	0,34	1,47	1,41
1996	1,79	1,16	1,58	2,48	1,45
1997	1,5	1,59	1,59	0,91	0,95
1998	1,18	0,94	0,85	0,9	0,61
1999	0,58	0,48	0,73	0,88	1,45
2000	0,8	0,54	0,62	0,65	0,16

year	WINTER	SPRING	SUMMER	AUTUMN
1976	0,85	1,32	1,33	1,96
1977	2,29	1,45	1,06	1,03
1978	1,03	1,36	0,98	0,33
1979	1,87	0,62	0,14	0,8
1980	0,54	1,18	0,74	0,93
1981	0,09	1,36	0,61	0,07
1982	1,17	0,5	0,18	1,21
1983	0,57	0,49	0,04	1,05
1984	0,83	1,85	0,75	1,44
1985	0,63	0,6	0,1	0,95
1986	1,35	0,59	0,3	0,55
1987	1,15	0,28	1,99	1,26
1988	0,89	0,54	3,39	1,13
1989	0,66	0,95	0,47	1,49
1990	0,95	0,73	0,17	0,98
1991	1,2	1,27	0,13	1,32
1992	0,31	0,86	3,7	0,95
1993	0,36	1,77	0,47	1,88
1994	0,74	0,52	0,04	0,8
1995	0,2	0,58	1,15	1,49
1996	2,75	1,49	0,04	1,45
1997	2,07	0,42	1,92	1,63
1998	1,21	0,67	0,23	0,39
1999	0,68	0,63	0,62	1,11
2000	0,31	1,48	0,01	1,14

extreme drought: less than 70% of normal precipitation

severe drought: between 70% and 80% of normal precipitation

moderate: between 80 % and 90% of normal precipitation

midl: between 90% and 100% of normal precipitation

wet: 100% ans above of normal precipitation

Fig. 4. Ratio between the annual precipitation totals and the climatological means of 1961-90.

Conclusion

The changing climatic conditions together with extremes of events including recurrent drought in Morocco, as well as heavy precipitation, have negative effects on the water flow for about three decades. The trend toward stripping is associated with a significant decrease in soil water and this will have a huge impact on water ressources and vegetation.

Efforts of the Moroccan Meteorological Office will continue in order to deepen the understanding and to strengthen the means and techniques to monitor and to ensure the decision support to mitigate

References and Bibliography

Benichou, P. and Le Breton, O. (1986). Prise en compte de la topographie pour la cartographie des champs pluviométriques statistiques. *La Météorologie*, 19. Nobert Gerbier award..

Hevesi, J.A., Flinta, A. and Istok, J.D. (1992). Precipitation estimation in mountain terrain using multivariate geostatistique. *Journal of Applied Meteorology*, 31(7): 677-688.

Laborde, J.P. (1995). *Méthodes d'interpolation et géostatistique pour la cartographie automatique*. University Sophia Antipolis Nice, France.

Davitian, G. (1998). *Analyse des données et cartographie automatique: Applications aux variables climatiques*. PhD Thesis, University Sophia Antipolis, Nice, France.