Application of the drought management guidelines in Morocco [Part 2. Examples of application]

Ouassou A., Ameziane T., Ziyad A., Belghiti M.

in

Iglesias A. (ed.), Moneo M. (ed.), López-Francos A. (ed.).
Drought management guidelines technical annex

Zaragoza : CIHEAM / EC MEDA Water
Options Méditerranéennes : Série B. Etudes et Recherches; n. 58

2007
pages 343-372

Chapter 19. Application of the Drought Management Guidelines in Morocco

A. Ouassou*, T. Ameziane*, A. Ziyad and M. Belghiti*****

*National Drought Observatory, Central Unit, IAV Hassan II, BP 6202 Rabat-Instituts, Rabat, Morocco
**Ministère de l'Aménagement du Territoire, de l'Eau et de l'Environnement,
Quartier Administratif, Rue Ouarzazate, Hassan, Rabat, Morocco
***Ministère de l'Agriculture, du Développement Rural, et des Pêches Maritimes,
Av. Hassan II, BP 169, Rabat RP, Morocco

SUMMARY – The laws with regard to water management were seriously reviewed in 1995. The Administration is still largely in charge of the formulation of water policies. The consultative institutions issue recommendations and approve plans; while the stakeholders control over municipal water through the Local Authorities, which work under the supervision of the Ministry of Interior. However, slow change is taking place. When the drought cycle is over, the activity of the national inter-government committee is abandoned. Should the drought recur, the same procedures are reproduced regardless the results of the previous drought episode. There is however a renewed political will to move away from this crisis management to a more proactive drought management approach. This has been activated in 2001 by the creation of the National Drought Observatory in the form of an institutional network of representative stakeholders working on drought issues; the support of the insurance policy plans; and water saving operations. A methodology of drought characterization, risk analysis and vulnerability assessment in agricultural system is presented for Oum Er Rbia river basin.

Key words: Drought, legal framework, characterization, Oum Rbia Basin, agriculture, management.

The planning framework

Situated in the North Western part of Africa, Morocco is subject to the influence of highly diverse climatic conditions. The North is characterized by Mediterranean influences, the South is part of the arid Sahara, the West is subject to Atlantic influences and in the East the high Atlas has its own microclimates. Average annual precipitation levels vary from 750 mm per year in the Mediterranean region of Loukkos to under 100 mm in the Saharan regions of Ouarzazate and Tafilalet. Total precipitation levels for Morocco average 150 billion m^3 per year, 29 billion of which replenishes surface and groundwater flow, the remainder being lost to evaporation. About 20 billion m^3 of freshwater resources are available for mobilization, of which 16 billion m^3 as surface water and 4 billion m^3 as groundwater (Fig. 1).

The challenges associated with the uneven geographical distribution of Morocco's water resources are compounded by the uneven and erratic nature of rainfall. Most precipitation falls between October and April. Morocco is highly susceptible to long periods (one to six years) of drought. This creates highly variable surface flows and threatens water supplied to households and farmers alike. According to official figures of Secretary of State for Water (MATEE, 2004), and with renewable freshwater availability, per capita water resources are estimated at only 700 m^3/person/year. Morocco is well below UNDP's scarcity criterion of 1,000 m^3/person/year. Moreover, water is becoming scarcer due to demographic and economic growth pressures, limited potential for increased resource mobilization, and periodic long droughts. By 2025, about 35 percent of the population will be below the absolute scarcity threshold of 500 m^3/person/year; so that Morocco is to become a "chronically water-stressed" country (Bzioui, 2000).

Economic development in Morocco has always been dependent on the development of water resources which has facilitated agricultural and urban growth and played a vital role in poverty alleviation. Because agriculture provides a livelihood to 43 percent of the economically active population, and contributes around 15 percent of GDP, changes in output due to variations in weather and drought episodes have a multiplier effect on overall economic activity, with serious consequences for incomes.

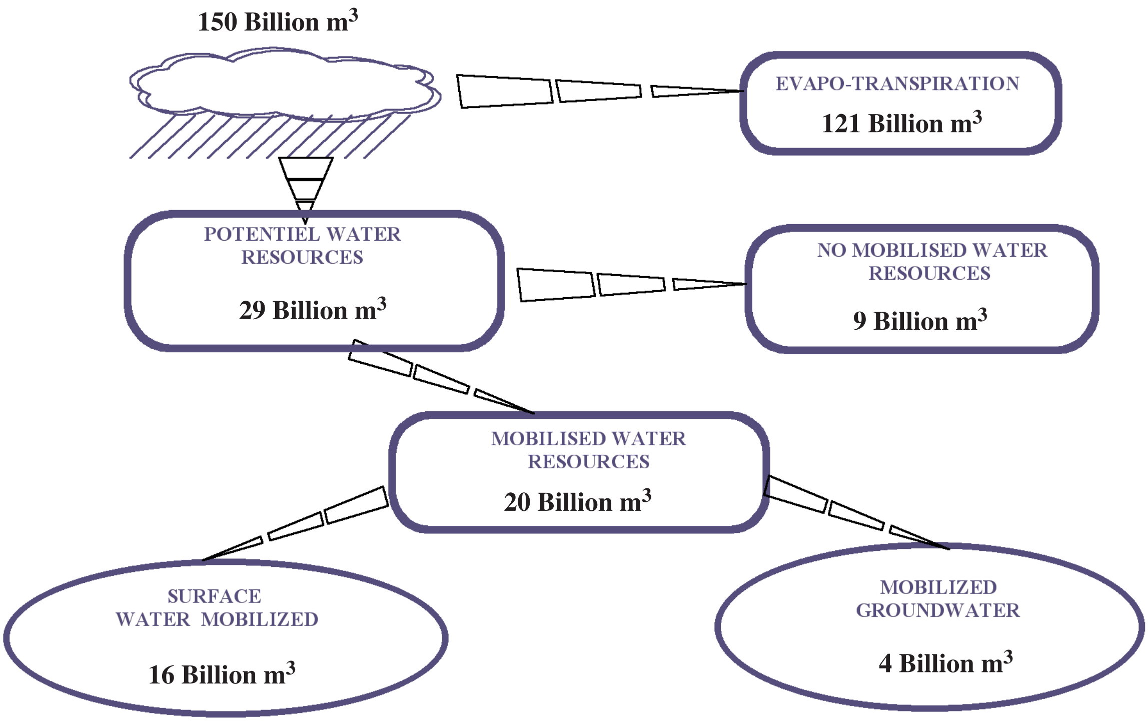


Fig. 1. Characterization of water resources in Morocco (DGH, 2004).

Of Morocco's 71.5 million hectares, 21 million are classified as rangeland and 9 million as cultivable land. Due to cropping patterns that include fallow periods, actual area cultivated in any year averages 7 million hectares. Irrigated agriculture is an essential pillar of economic and social development in Morocco. Morocco's 1.4 million hectares of irrigated crops consume, on average, 85% of available water resources (as low as 60 to 70% in a dry year), while 12% and 3% of resources are used for public water supply and industry, respectively. The National Irrigation Plan aims at raising the efficiency of agricultural water use, through upgraded infrastructure, improved practices, and lower-demand crops (Yacoubi, 2000).

The Moroccan Government has recently redefined the irrigation objectives as: (i) contributing to food security by efficiently producing strategic food products; (ii) increasing agricultural incomes and employment by improving on-farm productivity and upstream and downstream linkages; (iii) conservation of natural resources; and (iv) encouraging the integration of agriculture into international and local markets. To achieve these objectives, it recognizes that greater attention needs to be paid to the conservation and protection of water resources and to increasing on- and off-farm water efficiency. Since the introduction of 1995 Water Law, the legal framework for achieving these new orientations has been in place. The 1995 Water Law marked a paradigm shift in the Government's water policies, from supply to demand management. With the new law, the emphasis changed from heavy investments in water resources development, which was almost complete, to better water use efficiency, resource allocation practices, and protection of water quality.

Organisational component

Legal framework

Legal aspects and history

Due to the nature of the climate in Morocco, irrigation has been introduced very early and rules on property, conflict resolution and ways of managing and realizing collective works for implementing irrigation networks have been defined, debated and written in the 9th century, after Islam was introduced in Morocco. The institutional setting was shaped by the laws inherited from Islam as interpreted by

Moroccan Ulema (Arabic word for jurist that interpret the tenets of Islam in order to complete and explain the rules derived from the Revelation), by the customs and rules developed in pre-Islamic Morocco.

A turning point occurred in 1912, with the Protectorate and the introduction of a "modern" legal system and juridical concepts. Thus, in Morocco, the first text concerning modern water legislation goes back to 1914 (Decree of I July 1914) recognizing water resources as a public good. That created a mixed system due to the prevalence of private appropriation based on the interpretation of Moroccan Ulema of Islamic Chariaa.

The legislation on water was further codified in 1925, with the adoption of the law on "Régime de l'Eau" (Water Rules) that develops on the public ownership of water and defines the conditions of water use and water access. It is completed by a decree stating the conditions for recognizing water rights. Beside the corpus on public ownership, the Protectorate issued a law regarding water users associations in order to formalize the implementation of a private irrigation network. The ASAP (Associations Syndicales Agricoles Privilégiées, 1924) were allowed to intervene on the public domain in order to realize irrigation infrastructure and received privileges in order to implement the network.

In 1995, a new legislation was voted by the parliament and adopted by the government.

The 1995 Water Law

The 1995 law called "Loi sur l'Eau" (Water Law) constitutes the main actual water legal frame. This law recognizes that all water resources are a public good and water should be managed at a river basin level. The law is authorizing the creation of river basin agencies, which, when fully established, will result in a more decentralized and participatory water management program. It also introduced a lot of new considerations about the management of water at the national, regional and local level.

The content of the 1995 Water Law is organized around the following points:

(i) An extension of the public ownership of water and the imposition of a time limit of 5 years to any claim on private water rights.

(ii) The introduction of the "Agence de Bassin" (Water Basin Agency), as the main entity in charge of water issues at the water basin level.

(iii) The official recognition of planning by the State of mobilization and allocation as the main instrument of decision about public infrastructure, water allocation and water transfer. The Water Basin Master Plan is to be prepared by the Agence de bassin and to be submitted to the Conseil Supérieur de l'Eau et du Climat (Superior Council for Water and Climate) for formal adoption. Once adopted, the master plan for an integrated management of water resource at the hydrological basin level becomes the main document to decide water allocation by sectors, abstraction agreement and concessions. It includes goals in terms of quality.

(iv) The introduction of new taxes, "redevance de bassin" based on water abstraction, and pollution taxes based on the contribution to the stream pollution. These taxes will cover subsidies in investment to reduce pollution, expenditures related to the network of observation in the basin, the definition of the master plan of water mobilization and allocation at the basin level and management of the agency.

(v) The introduction of new instruments to deal with pollution and drought: Fees for polluters, subsidies for investment to reduce pollution and exceptional power to the administration for dealing with drought. In the case of acute drought, a decree defines the area where the administration receives such powers that allow for reduction in abstraction, and obligation of use of underground resources.

(vi) The formal introduction of the National Hydrological Plan was to be presented to the Superior Council for Water and Climate, to solve allocation conflicts and make recommendations.

Stakeholders and their participation

In the board of the River Basin Agencies, a third is composed from the administration; a quarter from public enterprises and the rest (42%) represents users. In conducting irrigation projects, it is very recently within the framework of AUEA (Water Users' Associations) Law, 1990) that users have a say on the project.

Reforms and changes

In the current setting, stakeholders do not have always a proper say on water issues, except locally by the control over municipal water through the local authorities (collectivities locales), which work under the supervision of the Ministry of Interior. However, slow change is taking place. This change will be supported because NGOs and civil society are more active in this field, and water user associations are gaining more autonomy in their dialogue with the administration.

Institutional drought management

Water resources management overview

The main institutional stakeholders in the water sector are represented by the key ministerial departments including agriculture, water and environment, local authorities (Ministry of Interior), Health, Energy and Mines, and Finance Departments (Fig. 2). NGO's such as water user associations, and natural resources / environment protection associations are also actively operating in the country in response to civil society's needs.

MAIN ADVISORY AUTHORITIES

Superior Council for Water and Climate (SCWC)
National Council for Environment (NCE)
Council for Agricultural Development (GCAD)
Permanent Inter-Ministerial Council for Rural Development (PICRD)
National Drought Observatory (NDO)

EXECUTIVE ADMINISTRATION AUTHORITIES

Ministry of Territorial Administration, Water & Environment (MTAWE)
- Secretariat of SCWC
- Directorate General of Hydraulics (DGH)
- National Meteorological Office

Ministry of Agriculture and Rural Development (MARD)
- Water & Ag – Engineering Administration (AGR)

High Commissariat of Water, Forest and Fight against Desertification
Ministry of Interior (MI)
- Directorate General of Local Collectivities
- Directorate of Régies & Conceded Services

Ministry of Finance (MF)
Ministry of Health (MH)
Ministry of Energy and Mines (MEM)
Ministry of General Affairs (Prices Directorate) (MGA)

PUBLIC OFFICES, AGENCIES & PRIVATE OPERATORS

River Basin Agencies (MTAWE)
Directorate General of Hydraulics (MTAWE)
National Water Drinking Office (ONEP - MTAWE)
Regional Office for Agricultural Development (ORMVA - MARD)
Autonomous companies and private operators (REGIES – MI)
National Office of Electricity (ONE – MEM)

WATER LOCAL

Water Provincial Commission
Local Collectivity Representatives
Water Users Associations (AUEA)

Fig. 2. Main stakeholders in water sectors in Morocco.

The current institutional setting does not clearly define the scope of intervention of each ministerial department. However, it addresses the issue of coordination through consultative institutions at the national, regional river basin and local levels, and through the executive central administration authorities. The overall coordination is the role of the Directorate General of Hydraulics (DGH, State Secretary for Water) with a strong involvement of the Water and Agricultural Engineering Administration (AGR, Ministry of Agriculture). Decisions related to water resources management are implemented by the Public Offices and Agencies which operate under the supervision of their respective ministries: ONEP (National Office for Drinking Water) for drinking water, ORMVA (Regional Reclamation land Offices) for irrigation and ONE (National Office for Electricity) for hydropower. The general model for water management in terms of decision making, coordination and implementation at the national, regional and local levels includes advisory bodies and the executive authorities at the different levels (Fig. 3).

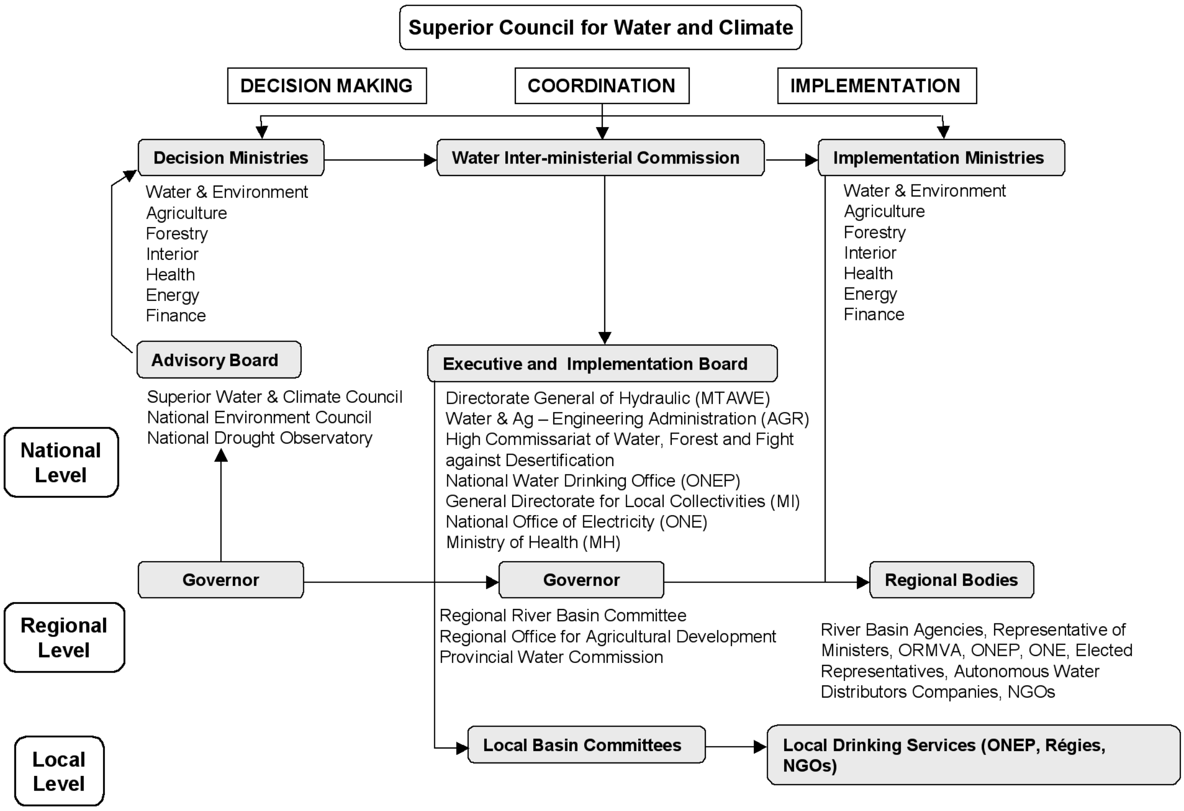


Fig. 3. Water resources management in Morocco.

Consultative institutions and bodies

The Superior Council for Water and Climate (SCWC)

The main consultative body, the Conseil Supérieur de l'Eau et du Climat (Superior Council for Water and Climate, SCWC) includes all administrations involved in the water sector, representatives of the parliament, of users and nominated experts that have competencies on the water issues. The SCWC convenes to address issues of national importance and formulate recommendations on the options of planning, mobilization and management of water resources.

The National Council for Environment (NCE)

The National Council for Environment (Conseil National de l'Environnement, CNE) was created in 1981 but has been reactivated only in 1995 in order to advise the Government on all environmental issues. On water issues, the NCE contributes to define guidelines that limit conflicts between institutions and promote environmental awareness and education.

The Permanent Interministerial Council for Rural Development (PICRD)

The Permanent Interministerial Council for Rural Development (Conseil Interministériel Permanent du Développement Rural, CIPDR) was created in 1999 following the severe drought episodes in Morocco. The main activities of the Council relate to the declaration of drought onset, the preparation of the National Drought Plan, the supervision of the planned drought actions and the elaboration of rural development strategies for Morocco.

The National Drought Observatory (NDO)

The National Drought Observatory was created in 2001 as an entity attached to the General Secretary of Ministry of Agriculture and Rural Development and based at the Institut Agronomique et Vétérinaire Hassan II (IAV), as a result of a ministerial decision to locate it physically in an academic institution allowing multidisciplinary collaboration, and giving it certain neutrality with regard to policy pressures. The main mission of the Observatory is to provide decision makers with decision support tools for drought management and to advise on strategic drought planning, preparedness, mitigation and response.

The General Council for Agricultural Development (GCAD)

The main role of the General Council for Agricultural Development (Conseil Général du Developpement Agricole, CGDA) is to make studies and recommendations pertinent to policies for agriculture development including contributions to policies on sustainable use of water and other natural resources, economic policies and social development issues.

National Executive Institutions

The Executive institutions in charge of advising the various line agencies and ministries, issue recommendations and approve plans. These institutions are the following:

Ministry of Water (State Secretary for Water, within MTAWE)

The ministry has an organization related to water, as follows:

(i) The Directorate General of Hydraulics, DGH (Direction Générale de l'Hydraulique) is in charge of policy formulation and implementation in planning, mobilizing, managing and protecting quality of water resources. It is also responsible for the all large infrastructure projects, in terms of implementation, management and maintenance.

(ii) The National Office for Drinking Water (Office National de l'Eau Potable, ONEP) is an autonomous institution which has more operational duties. It is in charge of planning all operations related to potable water and to implement the investments needed.

Ministry of Environment (as State Secretary for Environment within MTAWE)

The main attribution of the State Secretary for Environment is to prepare a strategy for the preservation of the natural environment. The Ministry contributes to the master plans on water resources and is in charge of water quality issues.

Ministry of Agriculture and Rural Development

The Ministry of Agriculture and Rural Development has two main duties in terms of water management: irrigation and watershed management. Two Administrations define and implement its policies in the Water sector:

(i) *The Water and Ag-Engineering Administration (Administration du Génie Rural, AGR)* plans and realizes all projects related to irrigation and drainage. It supervises the ministry regional structures for water management, the "Office Regional de Mise en Valeur Agricole" (ORMVA) (Regional Land Reclamation Office) which implements, operate and manage the Large Scale Irrigated (LSI) projects and all the Small and Medium Scale Irrigated (SMSI) projects.

(ii) *The Water and Forest Administration (Administration des Eaux et Forêts et de la Conservation des Sols, AEFCS)* prepares watershed management plans and projects and regulates access to continental fishing. Late in 2003, this Administration was transformed into the High Commissariat of Water, Forest and Fight against Desertification (Haut Commissariat aux Eaux et Forêts et pour la Lutte contre la Desertification, HCEFLCD).

Ministry of Interior

The Ministry of Interior is involved in the water sector as the tutor of local collectivities (Communes, provinces and regions). It is directly involved in the management and supervision of municipal water distribution and sewage.

Ministry of Health

The Ministry of Health is responsible for mineral water agreement and control, and is also in charge of all health issues related to water projects and water quality.

Ministry of Energy and Mines

The Ministry, through the National Office of Electricity (Office National de l'Electricité, ONE), is in charge of all hydropower projects and operations. As a user, it has a say on the planning of water resources, and water management especially during drought periods.

Regional and Local Institutions

In order to deal locally with the issues of implementation, management and coordination, a set of line agencies and consultative bodies were progressively set up. This policy has led to the creation of the Regional River Basin Agencies as autonomous public institutions which group all the water stakeholders and users in the region. The Regional River Basin Agencies (Agences de Bassin) are the most important institutions at the regional level; they are charged to manage the water resources at the basin level and monitor quantity and quality of surface and underground water. They also contribute to drought management and adjust water allocation according to available resources. Their effective implementation is, however, yet to come. Figure 4 shows the hydrological basins of Morocco.

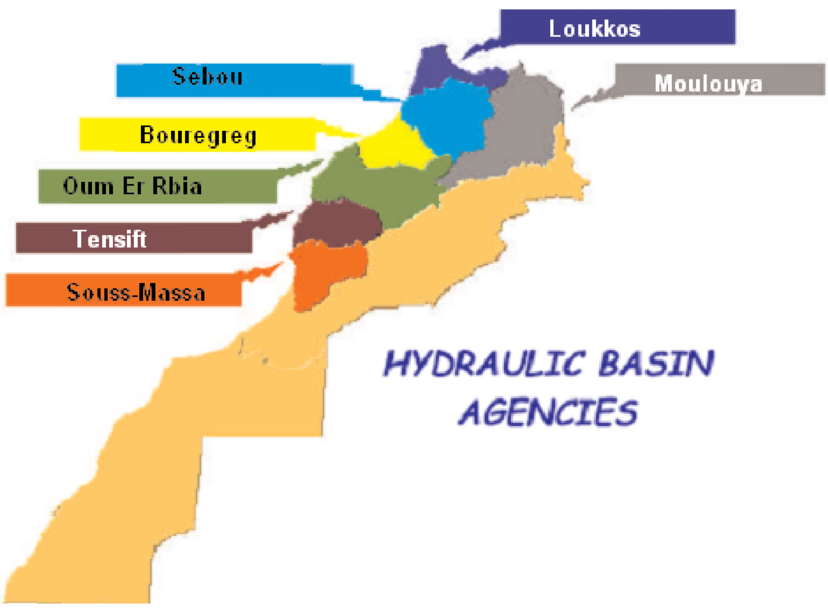


Fig. 4. Hydrological basins of Morocco.

The local authorities are fully responsible for water distribution and sewage system in their commune, under the supervision of the Ministry of Interior, since the adoption of the commune regulation "Charte Communale", in 1976 (recently revised), the cornerstone of the Moroccan decentralization policy.

The Offices Régionaux de Mise en Valeur Agricole (ORMVA) implement the irrigation projects, manage the network, enforce the water police and promote good agricultural practices through extension.

The Conseils Régionaux de l'Environnement (CRE) are to inventory regional environmental issues, including those related to regulation and implement recommendation of the CNE, the National Environment Council. They group representatives from the local administration, the local authorities and elected members of the local collectivities.

Water users associations

The water users associations (WUA or AUEA) constitute a very important institution in dealing with coordination problems at the irrigated perimeter level. Traditional water user associations, informal with regard to the current legislation, played an important role in coordinating efforts to realize collective infrastructure and irrigation water management particularly at the canal level ("Seguia") Informal water user associations still manage the operations of drought and the newly created legal status of AUEA is largely used by AGR in order to promote Small and Medium Scale Irrigation perimeters or to realize new projects with more flexibility than in the past.

Methodological component

Before performing the drought risk characterization and risk analysis for the case study of Oum Er Rbia River Basin, important features of meteorological, hydrological and agricultural droughts are presented for Morocco as a hole and compared for main agro-ecological zones including Oum Er Rbia region. Both historical and recent droughts are considered.

The national drought context

Meteorological drought

Historical droughts and long term drought frequency

Preliminary analysis of some of the longer and more climatically sensitive Moroccan tree-ring series (Ambroggi, 1988; Stockton, 1988) suggest the appearance of a periodicity of about 20 years in drought recurrence.

The long term drought frequency as determined by tree ring techniques is summarized in Table 1 which traces back ten centuries of drought history in the Col Zad area of central Morocco. Drought is defined as tree-ring values of 70 percent of normal or less.

Table 1. Number of droughts occurring in north central Morocco during the period 1000-1984 as inferred from the Col Zad tree-ring series

Drought length	Number of occurrences	Time interval between occurrences (years)
1 to 6 years	89	11.0
2 to 6 years	35	28.5
3 to 6 years	9	113.7
4 to 6 years	6	182.0
5 to 6 years	4	303.3
6 years	3	455.0

Source: Adapted from Chbouki (1992) by Ameziane and Ouassou (2000).

Recent droughts at the national level

An investigation by Chbouki (1992) completed with recent observations showed that Morocco often knew in the past periods of intense drought, and allowed to identify, since 1896, twelve main very dry periods that were generalized in the major parts of the country and had moderate to strong intensities: 1904-05; 1917-20; 1930-35; 1944-45; 1948-50; 1960-61; 1974-75; 1981-84; 1986-87; 1991-93; 1994-1995 and 1999-2003. The other, less generalized ones are the years 1906-07; 1910-14; 1924-53; 1965-67 and 1972-73.

The agricultural seasons of 1944-45, 1982-83, 1994-95 and 1999-00 were among the driest years of the recent climatological series as their rainfall deficits were generalized and very important.

Hydrological drought

In Morocco dams reserves are generally for multiple purposes such as drinking water, irrigation and hydro-electricity power. The dam's role was particularly highlighted during the recent droughts which the country has experienced. Without the water stored in dams, the water supply of the main cities of the country and of agricultural perimeters would have been disrupted in a considerable way. The most recent striking droughts from hydrological point of view were those of episodes from 1980-81 to 1985-86; 1991-92 to 1994-95 and 2000-2001 to 2002-2003 (Fig. 5).

These dry years profoundly aggravated the chronic deficit of the water flow. Average surface water inflow estimated to about of 19 billions of m^3, were reduced to values of 10 billions of m^3 for the period 1980-85 to 4.9 billion in 1992-93 and 5.3 billion in 1994-95. The year 1991-92 registered a contribution of 10.8 billions of m^3.

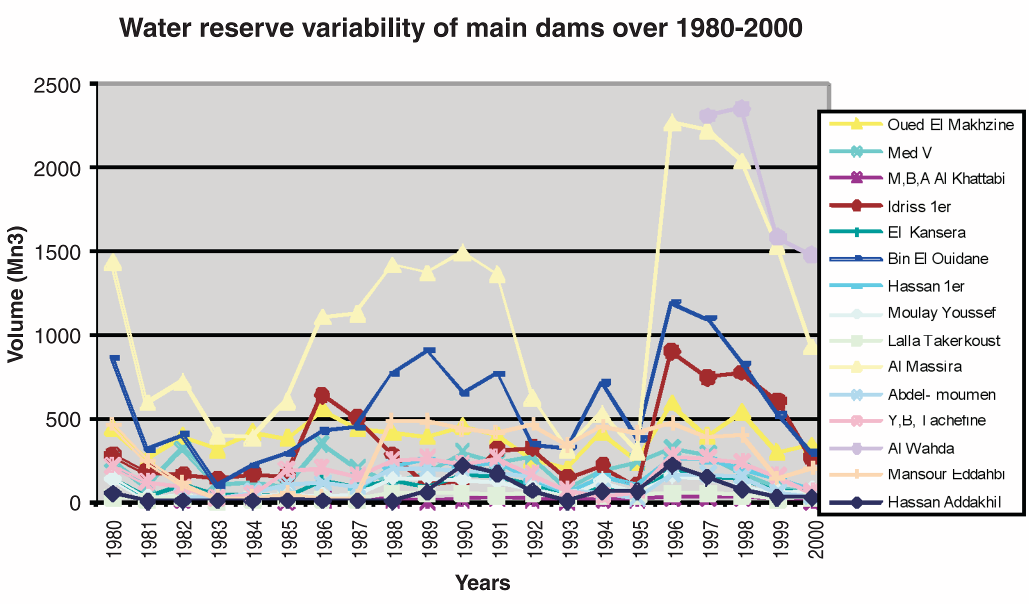


Fig. 5. Water reserve variability of the main Moroccan dams from 1980-2000.

Impacts of recent droughts

The recent drought episodes from 1980-81 to 1985-86, 1991-92 to 1994-95 and 2000-2001 to 2002-2003 engendered net declines of dam's water reserves and of the underground water levels, limitation in drinking water and irrigation water supply. Drought effects resulted also in the degradation of water quality in terms of increased water pollution leading to fish death, dysfunction or break service of drinking water treatment plants, and increase of waterborne disease. Hydraulic production underwent drought impact because of water stocks decline and fall height of all dams. Finally, drought episodes greatly affected agriculture production, livestock and their contribution to overall gross domestic production (GDP).

Drought characterization and risk analysis in the Oum Er Rbia Basin

The MEDROPLAN project team selected the Oum Er Rbia River Basin, Tadla region, as the main geographical unit for drought characterization, drought impact evaluation and risk analysis studies.

The Oum Er Rbia Basin

The Oum-Er-Rbia Basin, situated in the center of Morocco, extends over a surface of 35,000 km^2 (Fig. 6). The Oued Oum Er Rbia River, 550 km in length, takes its origin in the Middle Atlas 1800 m of altitude, crosses the chain of the Middle Atlas, the plain of Tadla and the coastal Meseta and sheds into the Atlantic Ocean in about 16 km of El Jadida city. Streams of the area of study are constituted with the main Oum Er Rbia River and the main secondary rivers: Tessaout, Lakhdar and El Abid. Average water flow is approximately of 3400 Mm^3/year (period 1939/40-2002/03) with a maximum of 8300 Mm^3 and a minimum of 1300 Mm^3/year.

The basin also contains numerous superficial and deep water-tables. Water potential of these water-tables is estimated at 330 Mm^3/year and is used mainly for the private irrigation and in small and average hydraulics and for drinkable and industrial water supply. The contributions of numerous sources associated to the snow melting guarantee to the Oum Er Rbia River to be a very steady and the most regular stream of the country.

The basin knew an important hydraulic development from the years 1920-1930 with the realization of 5 big dams reservoirs (Dchar El Oued on high Oum Er Rbia, Bin El Ouidane on Oued El Abid, Moulay Youssef on Oued Tessaout, Hassan I on Oued Lakhdar and Al Massira on the low part of Oued Oum Er Rbia River) to satisfy the water requirements of the basin and the need for the northward transfers to satisfy the drinkable and industrial water supply (AEPI) of Casablanca and southward transfers for the irrigation in Haouz and Doukkala perimeters as well as the AEPI of Marrakech, Safi and El Jadida and for the hydroelectric production (Fig. 6).

The total surface irrigated, at present, with big hydraulics is of 280,500 ha. The water demand for irrigation of this surface is closely about 2500 Mm^3/year.

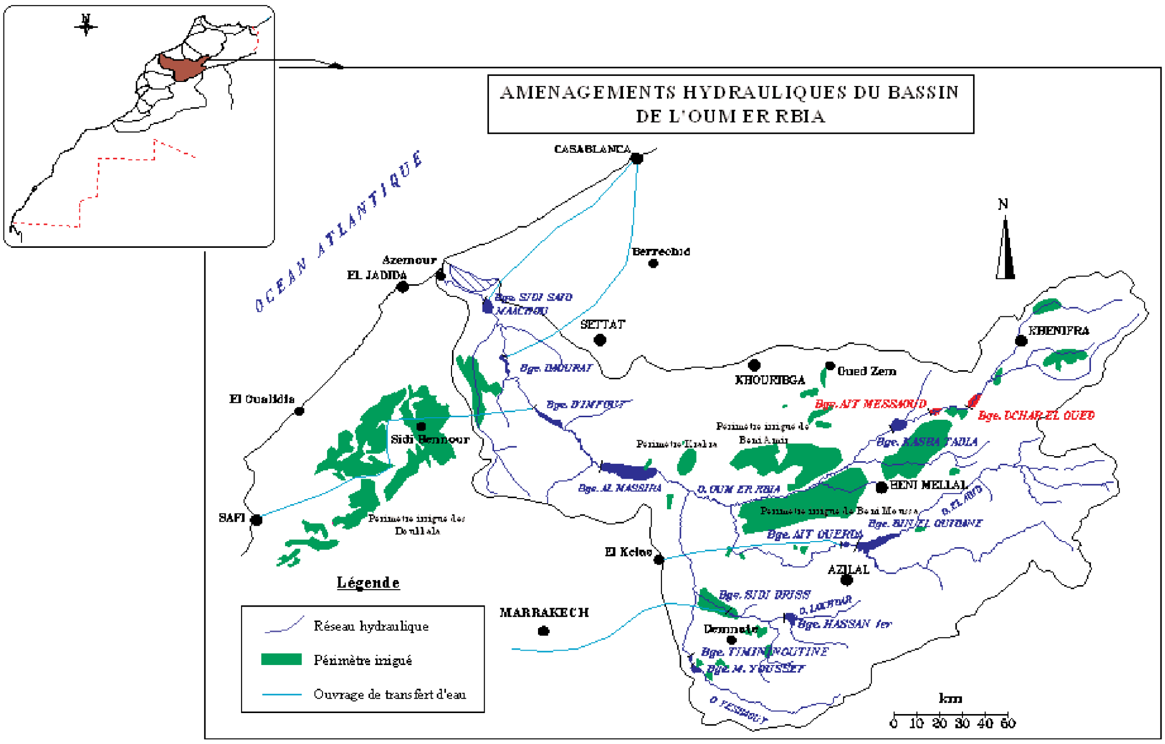


Fig. 6. Oum Er Rbia Basin (provided by the DGH of Morocco).

Drought characterization using drought indices and modeling tools

Several drought indices are used in Morocco to analyze drought patterns at the national and regional levels. Emphasis on drought risk analysis has been given at the level of Oum Er Rbia Basin.

Deviation from normal precipitation

The normal year retained for the purpose of risk analysis study relates to the period 1970-2001. The distribution of normal year precipitations among the main regions of Morocco is shown in Fig. 7.

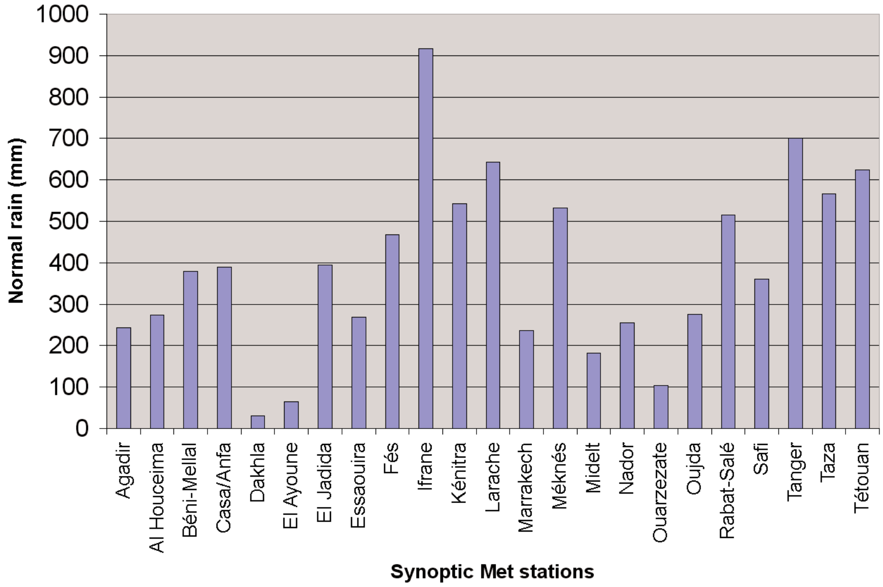


Fig. 7. Distribution of normal year precipitations among the main regions of Morocco (Period considered 1970- 2001).

Deciles analysis

Deciles analysis was performed for the period 1970-2001 at the national and regional levels. Deciles Indices (DI) are grouped into five classes, two deciles per class. If precipitation falls into the lowest 20% (deciles 1 and 2), it is classified as "much below normal". Deciles 3 and 4 (20 to 40%) indicate "below normal" precipitation; deciles 5 and 6 (40 to 60%) give "near normal" precipitation; 7 and 8 (60 to 80%) give "above normal" precipitation; and deciles 9 and 10 (80 to 100 %) are "much above normal" precipitation. The probability of occurrence of an expected level of cumulative annual rainfall for synoptic meteorological stations in Morocco is shown in Table 2; and Table 3 provides deciles analysis for selected stations. These data indicate that one year out of ten is expected to have a cumulative annual rain less or equal to 263 mm which is less than normal water requirements for a wheat crop.

Table 2. Deciles values for the synoptic meteorological stations in Morocco

Deciles	Decile1	Decile2	Decile3	Decile4	Decile5	Decile6	Decile7	Decile8	Decile9
Probability level	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Expected rainfall (mm)	263	309	353	371	394	427	447	495	551

Table 3. Deciles values for selected meteorological stations in Morocco, including the Tadla (Oum Er Rbia) region under the risk analysis study of the MEDROPLAN project. Units: mm/year

Station	Normal	Decile1	Decile2	Decile3	Decile4	Decile5	Decile6	Decile7	Decile8	Decile9
Settat	367	70	140	210	280	350	420	490	560	630
Khemisset	431	87	174	261	348	435	523	610	697	784
Taza	625	123	247	370	493	617	740	864	987	1110
Tanger	737	139	278	417	557	696	835	974	1113	1252
Safi	367	69	139	208	277	347	416	485	554	624
Oujda	313	63	126	189	252	315	378	440	503	566
Ouarzazate	120	22	44	66	88	110	132	153	175	197
Méknes	562	112	225	337	450	562	675	787	900	1012
Marrakech	240	48	96	144	192	240	288	336	384	433
Marchouch	406	77	154	230	307	384	461	538	614	691
Larache	675	127	255	382	510	637	765	892	1020	1147
Fes	525	106	213	319	426	532	638	745	851	958
Aoulouz (Agadir)	253	51	101	152	202	253	303	354	404	455
Azilal (Tadla)	526	101	202	303	404	506	607	708	809	910

Standardized precipitation index (SPI)

SPI is based on the probability distribution of precipitations and is reported to be able to monitor emerging droughts. The use of different time scales under the umbrella of the same index allows the effects of a precipitation deficit on different water resources components (groundwater, reservoir storage, soil moisture, streamflow) to be assessed. Positive SPI values indicate greater than median precipitation and negative values indicate less than median precipitation. The "drought" part of the SPI range is arbitrary split into near normal conditions (0.99 < SPI <-0.99), moderately dry (-1.0 < SPI < -1.49), severely dry (-1.5 < SPI <-1.99) and extremely dry (SPI < -2.0). A drought event starts when SPI value reaches -1.0 and ends when SPI becomes positive again. The positive sum of the SPI for all the months within a drought event is referred to as "drought magnitude".

SPI to date is finding more applications than other drought indices due to its limited input data requirements, flexibility and simplicity of calculations. The determination of SPI values for selected regions of Oum Er Rbia Basin was performed for different time steps and a summary is given by Fig. 8.

Surface water supply index (SWSI)

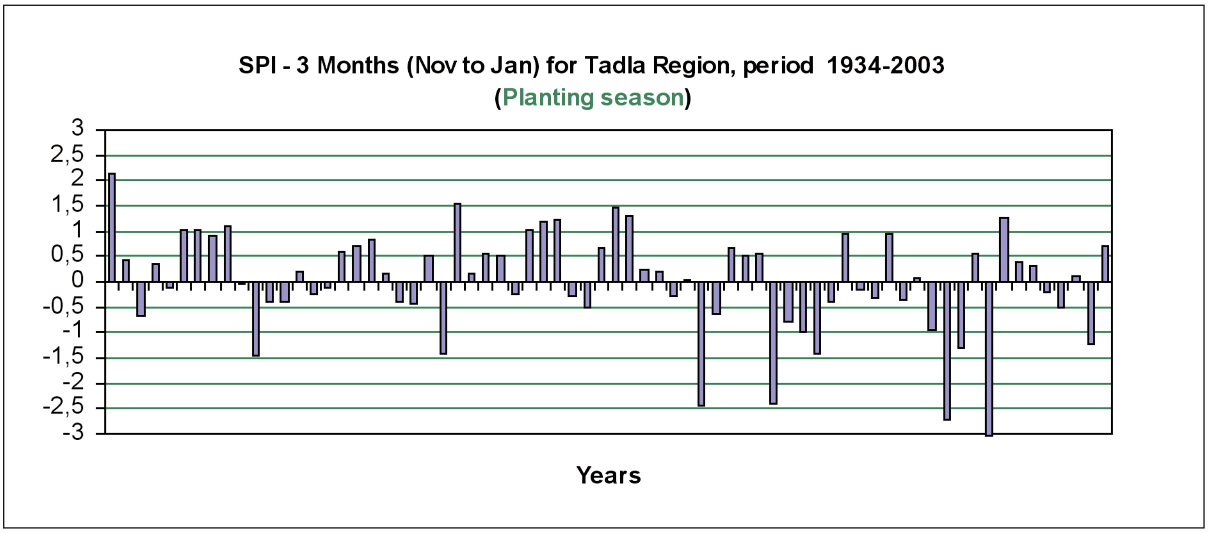
SWSI integrates reservoir storage, streamflow and two precipitation types (snow and rain) at high elevations into a single index number. SWSI is relatively easy to calculate and it gives a representative measure of water availability across a river basin or selected region/province. It is however unlikely that it could be successfully used for large regions with significant spatial hydrological variability. A modification of SWSI (Svoboda, 2004) was used for Morocco as in Fig. 9, namely:

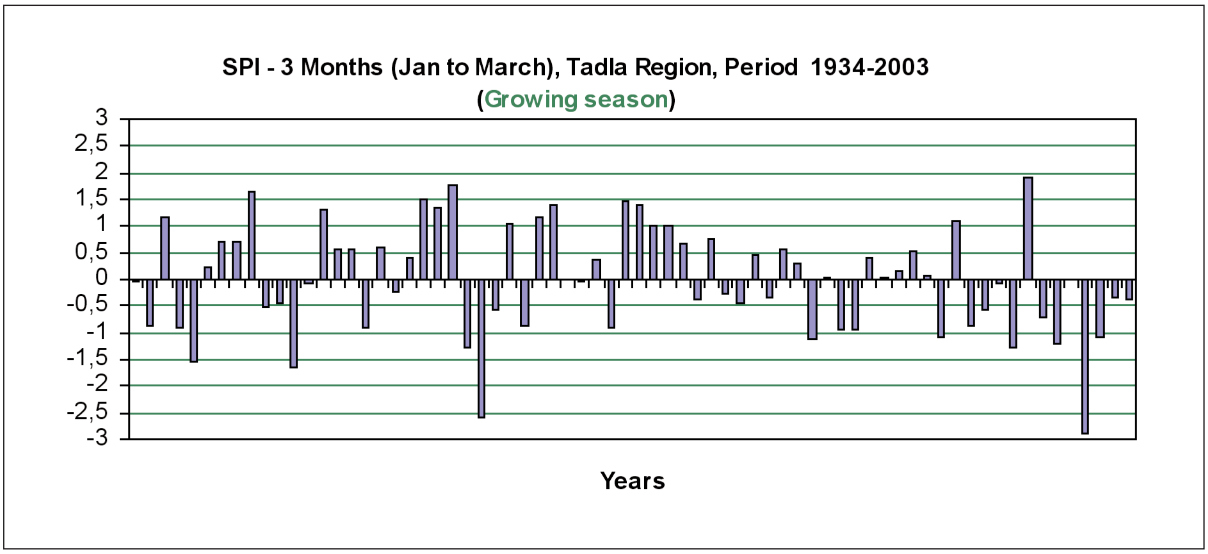
$$SWSI = (P - 50) / 12$$

where P = non exceedence probability (%) of reservoir storage + streamflow,
50 = centers the distribution on zero and,
12 = scales to existing ranges from -4.1 to + 4.1 for drought indices.

Use of RIBASIM Model

RIBASIM (River Basin Simulation Model) is a generic model package for analyzing the behaviour of river basins under various hydrological conditions (Delft Hydraulics, 2006).





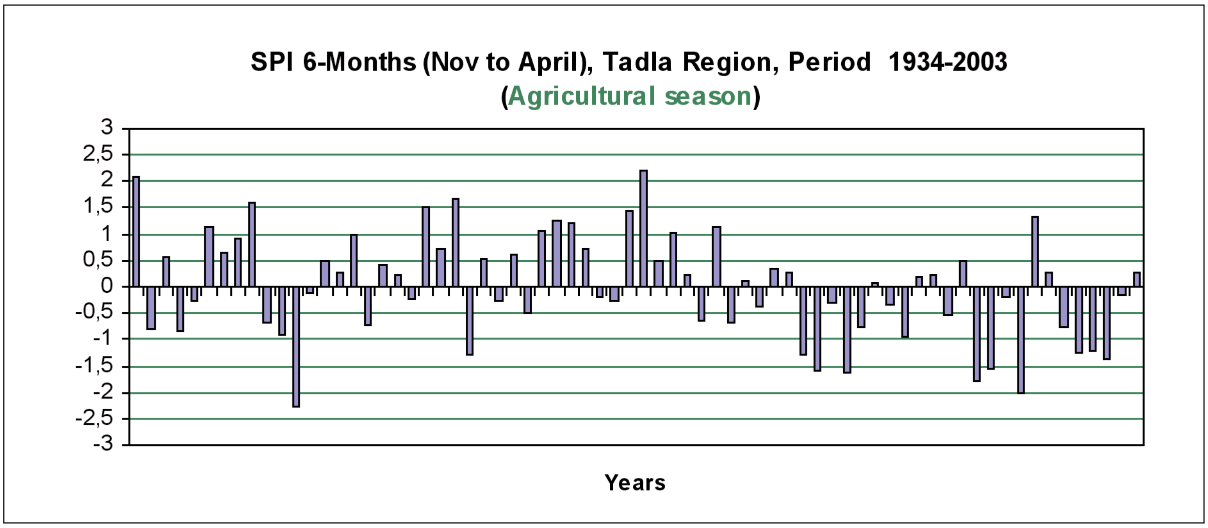


Fig. 8. Determination of SPI values at different time steps of cereal agricultural season for Tadla (Oum Er Rbia Basin).

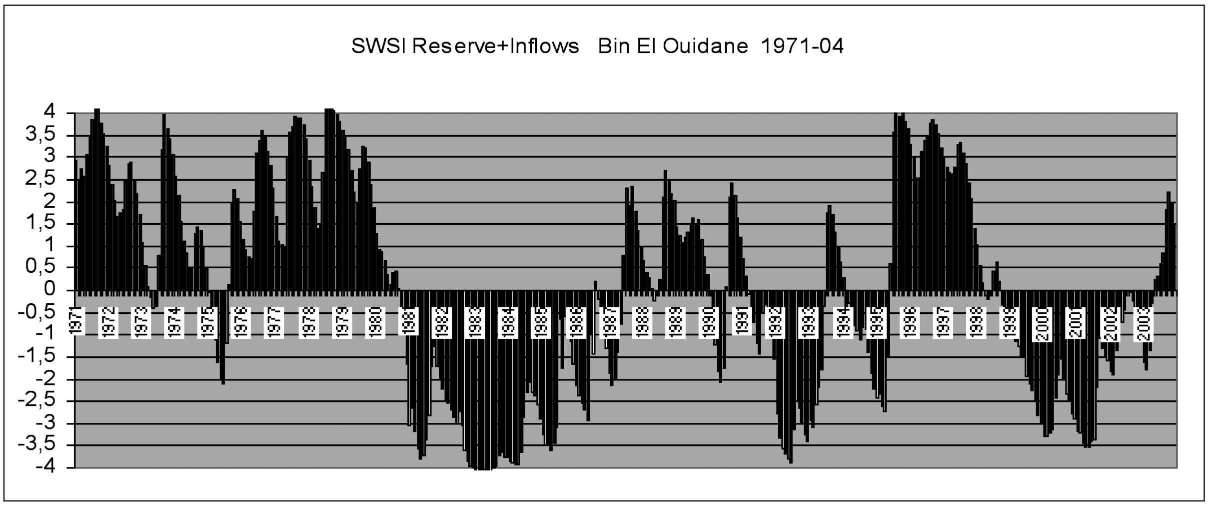


Fig. 9. SWSI values in the Oum Er Rbia River Basin over the period 1971-2004 for the Bin El Ouidane Dam.

RIBASIM enables the user to evaluate a variety of measures related to infrastructure, operational and demand management and the results in terms of water quantity and water quality. The RIBASIM model is currently used by water planners and managers within different big reservoirs in Morocco. It considers large number of variables to produce decision making tools at the river basin level. The inputs to the model are: water inflow; climatic data; dam reservoir characteristics; data from hydropower plants; data from water user sectors; and management rules. The outputs of the model are global basin water inflow, demand and supply in relation to probabilities of exceedence, and dam storage management curves which indicate different thresholds in relation to the water volume of the reservoir.

An example of such outputs is given in Fig. 10 for Bin El Ouidane reservoir in Oum Er Rbia Basin.

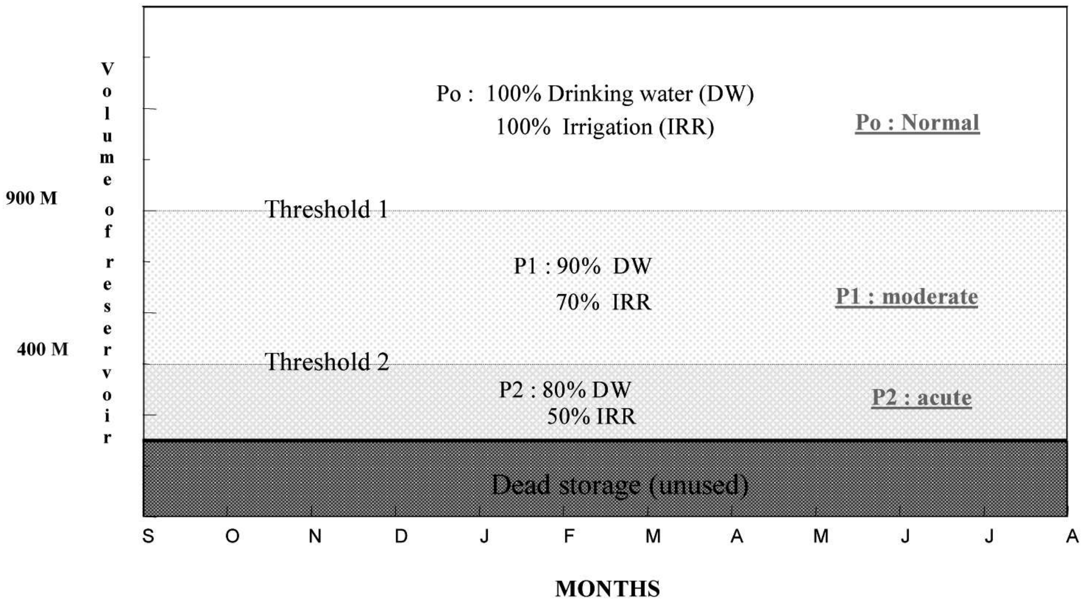


Fig. 10. Oum Er Rabia Dam storage management curve using Ribasim model.

Risk analysis in agricultural systems: Case Study of Oum Er Rbia Basin

A methodology is proposed to evaluate drought impacts and vulnerability and assess drought risks in agriculture. The analysis is applied at river basin scale by considering the case study of Oum Er Rbia Basin.

Methodology for Agricultural drought risk analysis and vulnerability assessment

Drought risk in agriculture is a product of both exposure to the hazard and the vulnerability of cropping practices in drought conditions. Therefore, the first step is to characterize drought hazard and then to assess the vulnerability of the agricultural system to the degree of exposure to this hazard. Impacts vary depending on type of production systems: rainfed systems, irrigated systems, and rangelands and livestock systems. Because of this diversity of impacts and vulnerabilities, adapted risk analysis methodologies and tools should be developed for each of these production systems. Here, focus is made on rainfed cereal production system in the river basin.

For this methodology, three steps have to be followed: (i) Characterization of drought hazard, (ii) Spatialization of drought hazard; and (iii) Drought vulnerability assesment

Step 1: Characterization of drought hazard in rainfed agricultural systems

In rainfed systems, cereals are the dominant crop and cereal yields are appropriate drought indicators. To characterize drought years, and their impact on cereal yields, two methods are used. The first is based on the yield threshold for profitability which is supported by field surveys and consists of defining a minimum yield level to cover the production charges for the crop to be profitable. The second method is based on the cereal production regression line over time which considers official recorded cereal yields to calculate the trend and its confidence intervals.

Once the dry years have been identified, several drought indices were tested for their predictive value of dry years. Among the tested drought indices, Deviation from Normal Rainfall, Deciles and Standardized Precipitation Index have proved to be simple and very useful for drought managers.

The relationship between the tested drought indices and cereal yields of dry years in different provinces within Oum Er Rbia River Basin is given in Table 4. The results clearly indicate the performance of SPI over the traditionally used indices for drought risk characterization. However, deciles analysis is also useful as complementary tool to characterize the extent of seasonal rainfall variability in order to make appropriate decisions, for example on crop planting in a given region.

Table 4. Correlation coefficients between cash a drought indices and cereal yield in different provinces of the Oum Er Rbia River Basin

Index	El Jadida	Khouribga	Settat	ElKalla	Safi	Azilal	Beni Mellal	Khenifra
SPI	0.74	0.76	0.73	0.65	0.75	0.58	0.63	0.65
% Deviation from normal	0.65	0.72	0.64	0.66	0.71	0.52	0.61	0.60
Deciles	0.65	0.72	0.64	0.66	0.71	0.52	0.61	0.60

Step 2: Spatialization of drought hazard

Drought spatialization is important for determining the vulnerable areas to drought over the entire basin. Mapping of drought risks can be performed by using any available drought index. However, for an adequate interpretation of the extent of drought within a given region and /or comparison of drought intensities between regions, SPI is best suited because of its standardised structure. SPI was used to map drought intensities over the Oum Er Rbia Basin, during the 1994-95 dry years and the 1995-96 wet years (Figs 11a and 11b).

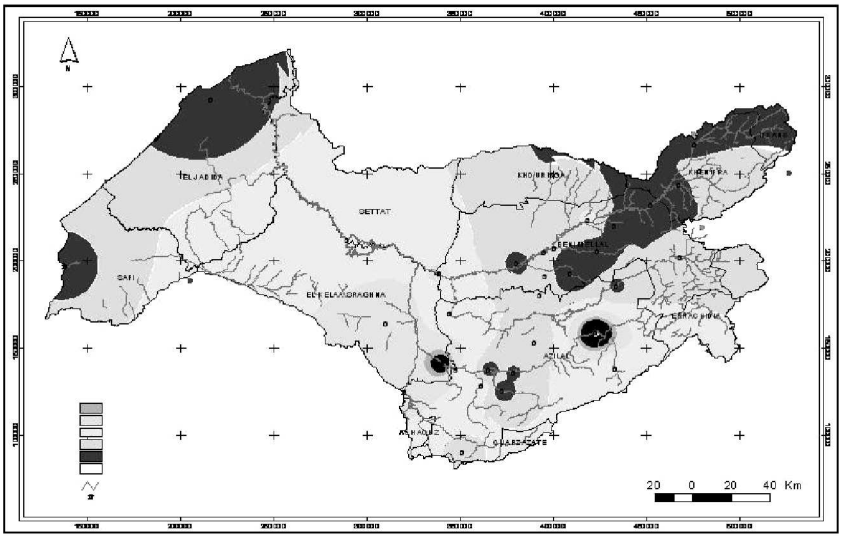


Figure 11a. Spatial drought characterization by SPI of the dry year (1994/95).

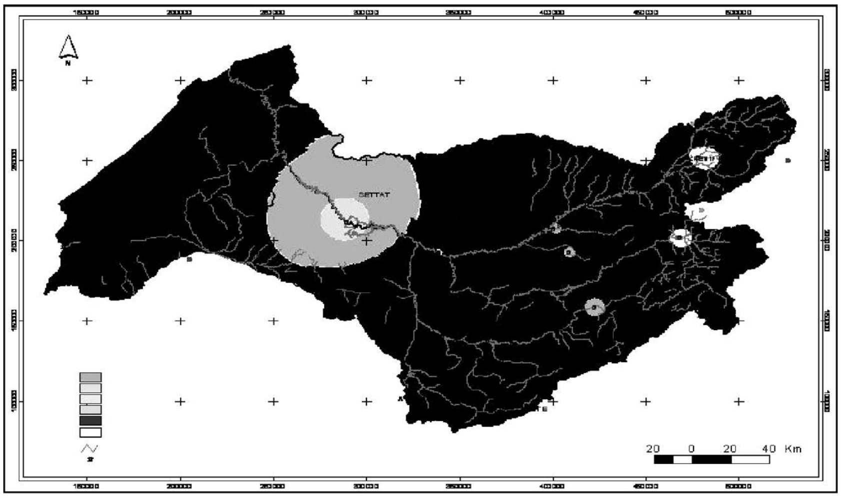


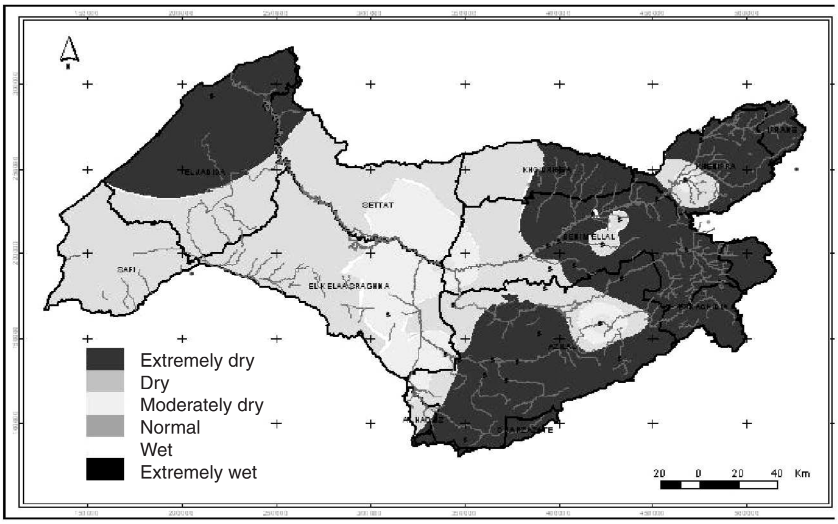
Figure 11b. Spatial drought characterization by SPI of the humid year (1995/96).

For the dry year 1994-95, the SPI was also used to map seasonal drought intensities for characterizing early season drought, mid-season drought and late season drought over the growing cereal crop cycle. The results are shown in Figs. 12a, b and c. The characterization of seasonal drought risk is important for farmers to select adapted crop species and appropriate planting dates, and for decision makers to decide whether or not to import cereal grains to meet domestic needs.

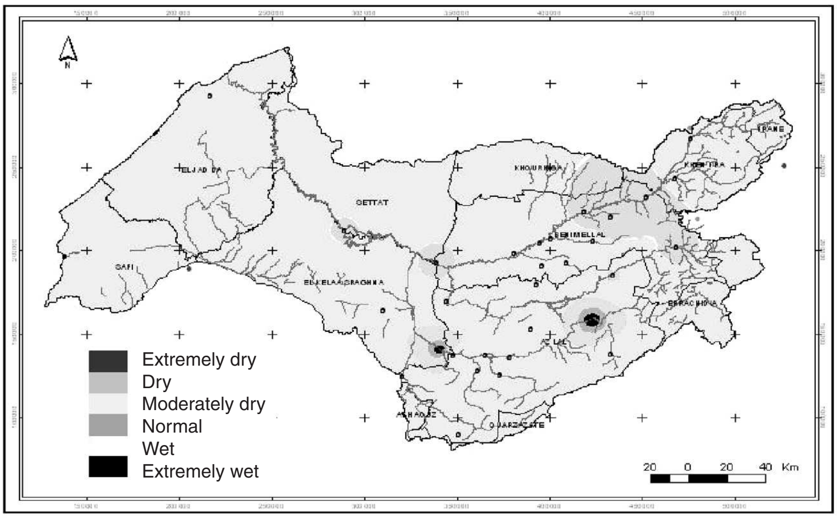
Step 3: Drought vulnerability assessment of agricultural systems

This method is aimed at establishing regional probabilities of crop vulnerability to agricultural drought following the methodology described by Wilhelmi (1999). A fundamental assumption underlying this approach is that the best characterization of the climatology of the basin from the agricultural drought vulnerability perspective is the probability of seasonal crop moisture deficiency. The agricultural drought begins when available stored water in the soil cannot meet the evaporative demands of the atmosphere. In order to determine the critical seasonal crop moisture thresholds for sustainable crop development and growth, seasonal crop-specific evapo-transpiration values were estimated.

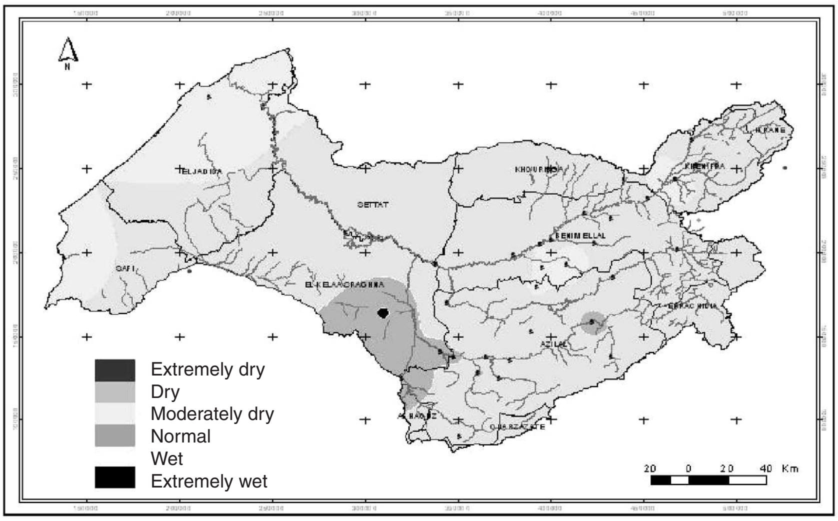
Droughts have spatial and temporal dimensions. The use of GIS for superposing data from different sources is found essential in many drought studies. The identification of key vulnerability



(a) Drought extent early in the season (Oct-Dec) as assessed by SPI.



(b) Mid season drought development (Jan-Feb) as assessed by SPI.



(c) Late season drought (March-May) as assessed by SPI.

Fig. 12. Seasonal drought characterization by SPI for the dry season 1994/95 in Oum Er Rbia Basin.

factors is based on their significance for agricultural sector. Analysis of drought in the Oum-Er Rbia Basin showed that biophysical factors, climate and soils, social factors, land use and irrigation, and socio-economic data such as sources of income, and the percent of acreage insured under crop in-surance are the most significant factors of agricultural drought vulnerability.

Following Wilhelmi (1999), probability of seasonal crop moisture deficiency, soil root zone available water-holding capacity, and land use types maps were combined to produce an agricultural drought vulnerability map; GIS was used to determine the area extent of combinations of classes present. A numerical weighting scheme was used to assess the drought vulnerability potential of each factor. This approach is similar to those described for food security mapping (Eastman *et al.*, 1997) and drought proneness mapping (Thiruvengadachari and Gopalkrishna, 1993). Each class of four vulnerability factors has been assigned a relative weight between I and 4, with 1 being considered least significant in regard to drought vulnerability and 4 being considered most significant (Table 5).

Table 5. Weighting scheme for assessing agricultural drought vulnerability

Agricultural drought vulnerability factor	Vulnerability class	Drought vulnerability classes score (weight)
Land use types	Forests and bare land	1
	Rangeland	2
	Rainfed cropland	3
	Irrigated cropland	4
Soil root zone available water holding capacity (mm)	More than 150	1
	100-150	2
	50-100	3
	Less than 50	4
Probability of seasonal crop moisture deficiency (%)	Less than 20 (low)	1
	20-40 (moderate)	2
	40-60 (high)	3
	More than 60 (very high)	4

The final result of the combination of factors was a numeric value calculated by simple addition of the weights. A high numeric value within each category was assumed to be indicative of an area that is likely to be vulnerable to agriculture drought. The resulting map is reclassified into 4 classes identifying geographic areas with "low", "low to moderate", "moderate" and "high" vulnerability (Figure 13).

Most rainfed cropland is assigned to the "moderately" vulnerability class because large part of the land receives enough rainfall for cereal production, combined with soil types and cropping patterns. However, during drought events, the crop can be significantly damaged and farmers' income reduced. While the rangeland area is assigned of "high-to-moderate" vulnerability class; most of it is located in area of low rainfall and shallow or sandy soils which significantly affect, during drought events, livestock forage production and water supply. With proper drought management, such as keeping appro-priate stocking rates and storing above-average levels of forage for livestock when rainfall is sufficient, vulnerability can be lessened.

The identification of agriculture drought vulnerability can be a step in reducing the impacts associated with drought; it will lead to adjustment in agriculture practices and incomes loss during drought years. The map of vulnerability can help decision makers visualize the hazard and take actions. However, drought vulnerability should also include socio-economic data such as sources of income, percent of acreage insured under crop in-surance.

The map of drought vulnerability can help decision makers visualize the hazard and communicate the concept of vulnerability to agricultural producers, natural resource managers and others to adjust agricultural practices and select more appropriate cropping patterns in order to alleviate reduction in crop yields and income loss during drought years. Vulnerability maps are also important tools to orient policies, strategies and actions at national, regional and local levels.

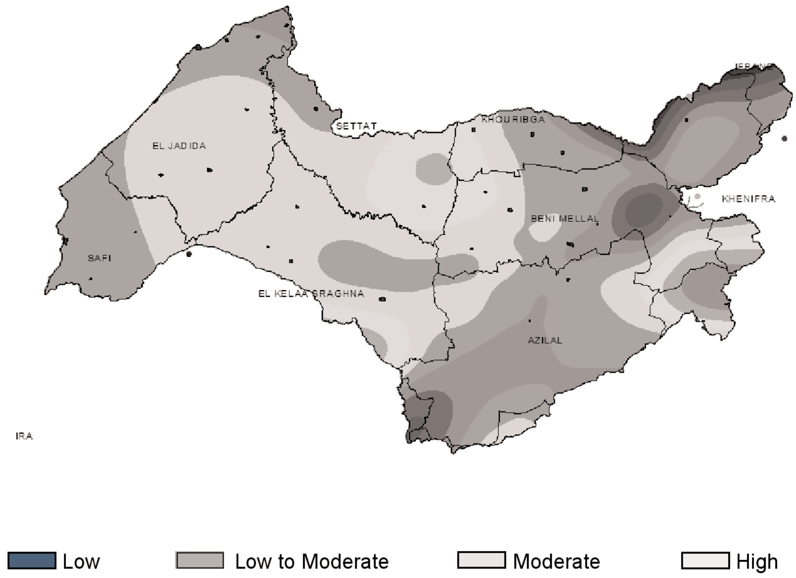


Fig. 13. Agricultural drought vulnerability of Oum Er Rbia Basin.

Operational component

Overall model of drought management in Morocco

This section describes the overall model for drought management in terms of decision making, coordination and implementation processes (Fig. 14). Overall coordination of drought management issues is the responsibility of the Permanent Interministerial Council for Rural Development (PICRD), which has ability to officially declare the onset of drought. The technical secretariat of this Council is under Ministry of Agriculture and Rural Development which heads the weekly periodic meetings of the Interministerial Technical Commission once a drought episode is declared.

National advisory board

In addition to the political board represented by the PICRD, the other members of the national advisory board on drought are the National Drought Observatory, the National Meteorology Office, the Superior Council for Water and Climate and the National Environment Council. The first two structures have advisory role to their respective ministry on a continuous basis while the last two others have much less frequent consultative role on drought issues.

National executive board

The Interministerial Technical Commission (ITC) is the basis of the executive board at the national level. It includes ministry representatives of Agriculture (MADR), Forestry (HCFWFD), Water (DGH, ONEP), Energy (ONE), Interior (MI), Health (MH), Finance and Credits (MF, CNCA). The ITC meets weekly to report to the Permanent Inter-Ministerial Council for Rural Development which, based on the Commission report and the information provided by the advisory bodies, may or may not declare drought and drought affected regions. If drought is declared nationwide, then the National Drought Mitigation Plan is set for execution. This is basically the reactive relief dimension of the plan that has to be implemented and supervised at the national, regional / provincial and local levels.

Regional and local setting of drought management

The Regional Drought Committee is headed by the Wali of the Economic Region. The regional drought committee is responsible for all decisions pertaining to the national drought mitigation plan related measures and actions to be implemented in the region. This committee includes representatives of key ministries (ONEP, ORMVA, DPA) and elected members of the rural and urban collectivities of the region, in addition to active NGO's operating in the region.

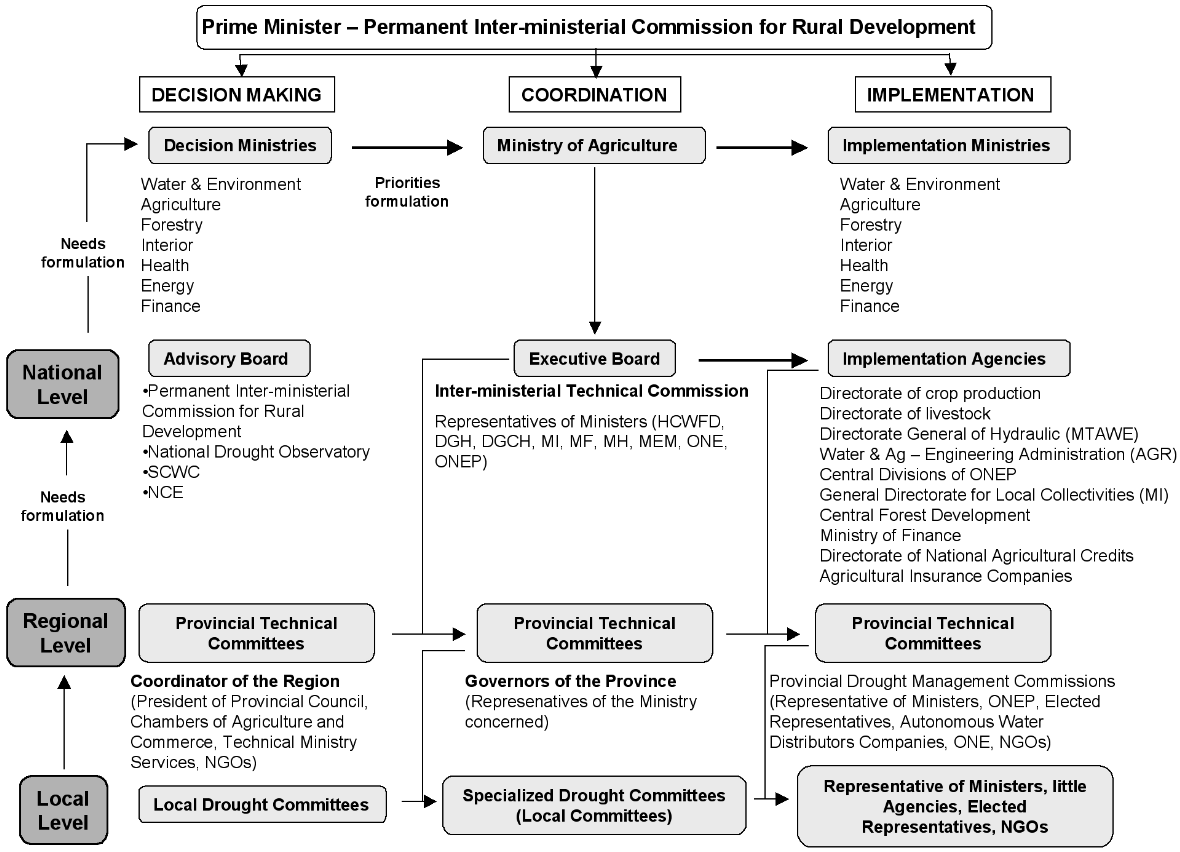


Fig. 14. Drought management in Morocco.

Current status of water and drought management and recent evolution

Actually, the State plays a major role in water resources management and is in charge of:

(i) Water mobilization

(ii) Irrigation water allocation

(iii) Water distribution

(iv) Water pricing

(v) Water allocation

(vi) Conflicts resolution

(vii) Registration of water rights

These multiple interventions have a huge cost to the State budget and have forced the Government to reconsider its options. It was estimated that the overall budget accounts for more than 90 % of total investment cost for irrigation. All the cost of water mobilization is also paid by the public budget. The cost of current policies explains the shift in favour of more involvement of the private sector and a change in cost sharing between the State and the water users.

Reactive and proactive action plans

Because of the severe droughts which dominated much of the country during the 1980's and occurred more frequently during the 1990's, the Government adopted in 1985 a reactive action plan to mitigate the drought effects in the form of relief operations which initially focused on population drinking water and livestock relief. However, the more dramatic subsequent development of the droughts and the growing awareness from the scientific community and civil society led the policy makers to adopt a more pro-active approach to this recurrent problem. As a result, the National Programme for Drought Mitigation has now two clear orientations, (i) an operationally oriented short term reactive programme with relief operations as the main focus, and (ii) a structurally oriented drought planning programme focusing on the long term pro-active approach to drought mitigation.

Consequently, a National Drought Observatory was proposed in 1999, and officially created in 2001 as a coordinating structure and also as a link between the scientific community working on various drought issues and the decision makers in charge of the drought mitigation activities.

National reactive plan for alleviation of drought effects

When a drought occurs nationwide, the policy so far applied consists of setting up a National Drought Programme. To implement the planned activities, funds are made available to combat the deleterious consequences of drought and to assist rural populations in solving the problems associated with, (i) drinking water, (ii) livestock protection, (iii) jobs creation, and (iv) agricultural credit debt relief. This is typically a crisis-management oriented approach whose cost is tremendous in terms of public money investment, time and human resource needs. For example, during the 1999 drought year, a total of MDH 3.18 billion (approximately USD 318 million) was allocated to the national drought relief programme, including 332 million dirhams for the drinking water component, 300 million dirhams for the livestock component, 1.91 billion dirhams to create job opportunities in rural areas, and the remaining was to cover the agricultural credit sub-programme.

Simplification of administrative procedures was proposed to speed up the execution of proposed drought mitigation activities and to improve their implementation efficiency. The procedures have been simplified with regard to: (i) definition of programme of activities to be undertaken to alleviate the drought impacts, (ii) visa and signing of the programme, and (iii) spending and payment regulations. For illustration purposes, the setting up of the programme of actions to be implemented is as follows: Description of detailed activities including clarifying the nature of operations, their locations, their costs, the schedules of realization and the budgetary lines for imputations. The programme must be established before the middle of April for urgent operations and before the end of April for the remaining activities to be realized between April and June. The proposed programmes of activities are then transmitted to the Prime Minister Cabinet and to the Ministry of Economy and Finances (Budget Directorate, General Control of the Spending and General Finance).

Meteorological drought and weather forecasts

Morocco has some 40 complete weather stations (called synoptic stations) operated by the Direction de la Météorologie Nationale (the National Meteorology Office). The Met Office has full-time meteorologists who monitor rainfall patterns and weather forecasts in relation to drought events, using different models and publishes a monthly newsletter on drought trends. Meteorological drought can be described in terms of reactive and proactive responses (Fig. 15). A series of triggers are used by Ministry of Agriculture for monitoring crop stage and the state of livestock and pasture, by Ministry of Water (as State Secretary) for monitoring and managing available water, and by Ministry of Communication for public awareness about development of the drought situation.

Agricultural drought – crop production and livestock

The reactive response to agricultural drought includes drought triggers, ministries involved to produce a national drought plan of action, the components of that plan and its implementation. The organization structure for implementation is shown in Fig. 16. Actions are of two kinds. A first series of measures concerns the financing of agricultural activities affected by the drought. Among these measures, a system of farmer insurance for cereal production failure, in case of drought, was also launched. A second series of measures concerns seed supplies, the objective being to increase seed availability for the next agricultural campaign.

The Crop Production Directorate collects information mainly through its regional structures. Every week during the drought period, a campaign document is prepared summarizing main events observed by province particularly on cereal growth and phenology development. This information –in addition to that provided by the Meteorological Office– is used to monitor the drought process during the growing season. Monitoring of dysfunction of market prices for basic commodities and agricultural inputs, along with pricing policies and subsidies during drought period is the responsibility of the Programming and Economic Affairs Directorate. Lack of a continuous recording system and of quantitative assessment of drought development in the different regions on a real time basis may be considered as the main weakness within the Ministry of Agriculture and Rural Development. Coordinating mechanisms for water management issues with the newly established Secretary of State for Water have yet to be reshaped.

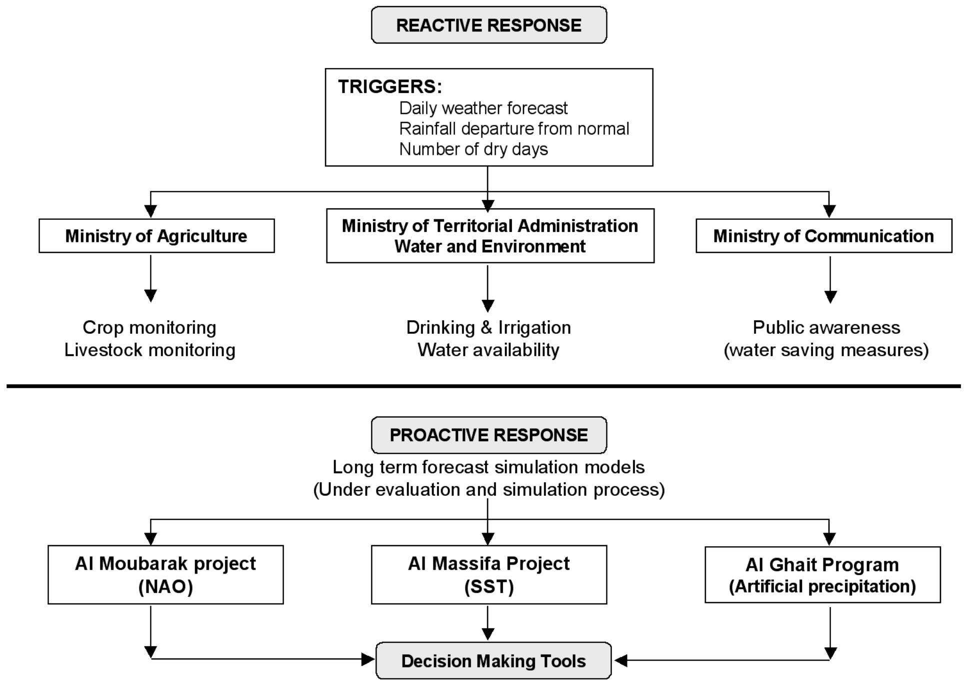


Fig. 15. Meteorological drought response in Morocco.

The Livestock Directorate receives information from Agriculture Provincial Directorates (rainfed areas) and from Agricultural Development Offices (irrigated areas), about the state of cattle feed supply, prices for animals and for feed, state of watering points for livestock, grazing land availability and herd sanitary states. Also, this Directorate closely monitors the animal feeding balance, and the imports of animals and animal products which are communicated by sanitary services control at country border. The livestock numbers surveillance system allows to control herd reduction during drought and to maintain a minimal population for reproduction. Collected information is analyzed by the services of this Directorate to elaborate necessary scenarios for decision-makers regarding livestock safeguard and protection. A weekly report is established on the drought impact situation and severity on animal productions. The main objective of the livestock safeguard and protection programme is largely to fill part of the fodder deficit to enable herders to overcome their financial incapacity to face important feed purchases to protect their herds. Under drought conditions, activation of the livestock safeguard plan is considered to be operational enough but independent evaluation of its impacts in different regions of the country is still to be carried out.

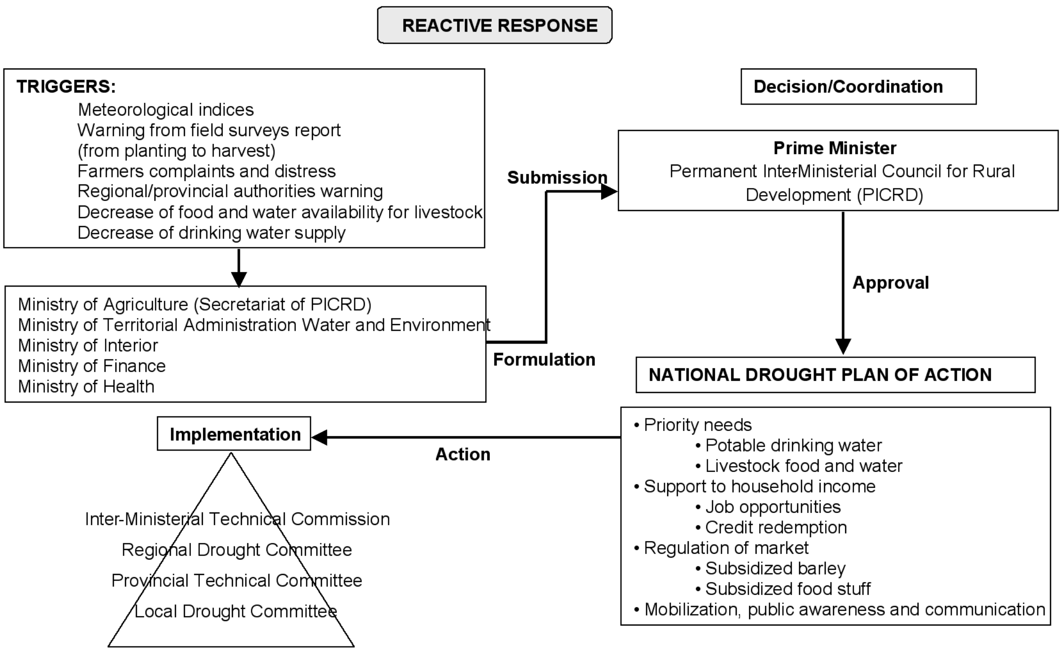


Fig. 16. Agricultural drought response in Morocco.

Hydrological drought and water management

The General Hydraulic Directorate has the responsibility of surface and underground water resources mobilization, water storage in the dams, and evaluates with the relevant structures of agricultural sector (mainly the Administration du Genie Rural, AGR) and other users the water needs throughout the drought period (Fig. 17). The evaluation is regularly made in joint meetings on the basis of indicators concerning the average rainfall deficit across the country, the amount of water stored in dams and the situation of the main groundwater tables. The outcome is a number of scenarios for water allocation by sectors (irrigation water, domestic, industrial). For each scenario, estimates are proposed to activate the water supply programme including: (i) Drinkable water supply of the urban and rural zones mostly affected by drought; (ii) Mobilization of water resources from groundwater by creation of additional water sources; (iii) Water supply for livestock in rural areas; and (iv) Water economy package including public awareness campaigns to adopt hygienic and water saving measures envisaged under drought conditions.

Responsibility for implementing the proposed measures is shared with other ministries departments and institutions, mainly Ministry of Agriculture and Office National de l'Eau Potable (National Office for Drinking Water, ONEP). The newly promulgated participation of the regional water basin agencies to decentralize decisions and to consider specific needs at the regional / local levels is an important element of equity. The participatory approach to decision taking with regard to water allocation under drought conditions is certainly a strengthening factor of the overall functioning of the system. However, conflicting views between the hydraulics and agriculture decision makers may alter the decision process with sometimes negative impacts on irrigated agriculture. This is particularly true when the level of stored water in the dams is not enough to have the right water allocation compromise between irrigation and other users.

Socio-economic drought

One of the major impacts of drought is the considerable loss of agricultural seasonal jobs and the risks of rural migration to urban areas which result from it. In order to maintain populations in rural zones, the Government has included in the national drought relief program job creation activities such as organization and construction of country roads, operations of land improvement like land stone clearing, and irrigation management operations of small and average hydraulic structures.

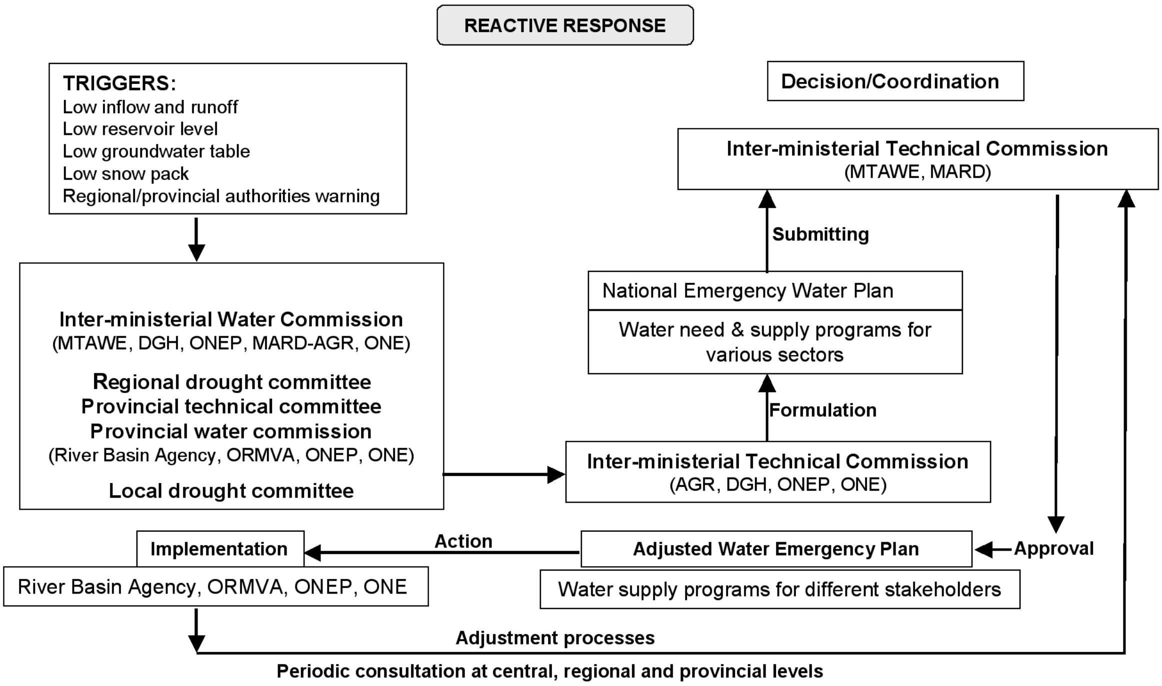


Fig. 17. Hydrological drought response in Morocco.

Proactive drought management

Following the severe drought episodes of the 80's, and the rising awareness among decision makers and the large public, the Government decided to set up a strategic drought planning and to move from the prevailing crisis management of the drought. In 1995, preliminary guidelines for a new approach to drought based on risk management principles provided the basis for a more proactive drought management approach in the country. The process is outlined in Fig. 18.

Working towards further development and implementation of this proactive approach, the Ministry of Agriculture and Rural Development and the Ministry of Public Works organized in 1999, in close collaboration with the Institut Agronomique et Vétérinaire Hassan II, an international workshop on "Drought management strategies in the Mediterranean". The purpose of this workshop was to gather information on the state of the art of drought planning and management by considering not only the local experience but also foreign experiences, with particular reference to Australia, South-Africa, Andalusia in Spain and to the US experience. The workshop recommended that promotion of risk management principles should be a key component of any strategy of drought management. It was also shown that drought risk management can be achieved by encouraging development of reliable climate forecasts and prediction, comprehensive early warning systems, preparedness plans, and mitigation policies and programs that reduce drought impacts and population vulnerability.

However, there are still weaknesses to overcome, the most important being:

(i) Institutional constraints associated with the major restructuring of the ministry departments dealing with water management.

(ii) Lack of availability of data and of clear mechanisms for the circulation of information as required by the proactive approach to drought management.

(iii) Lack of internal financial resources to meet the recurrent cost of the proposed activities for institutional capacity building in proactive drought management.

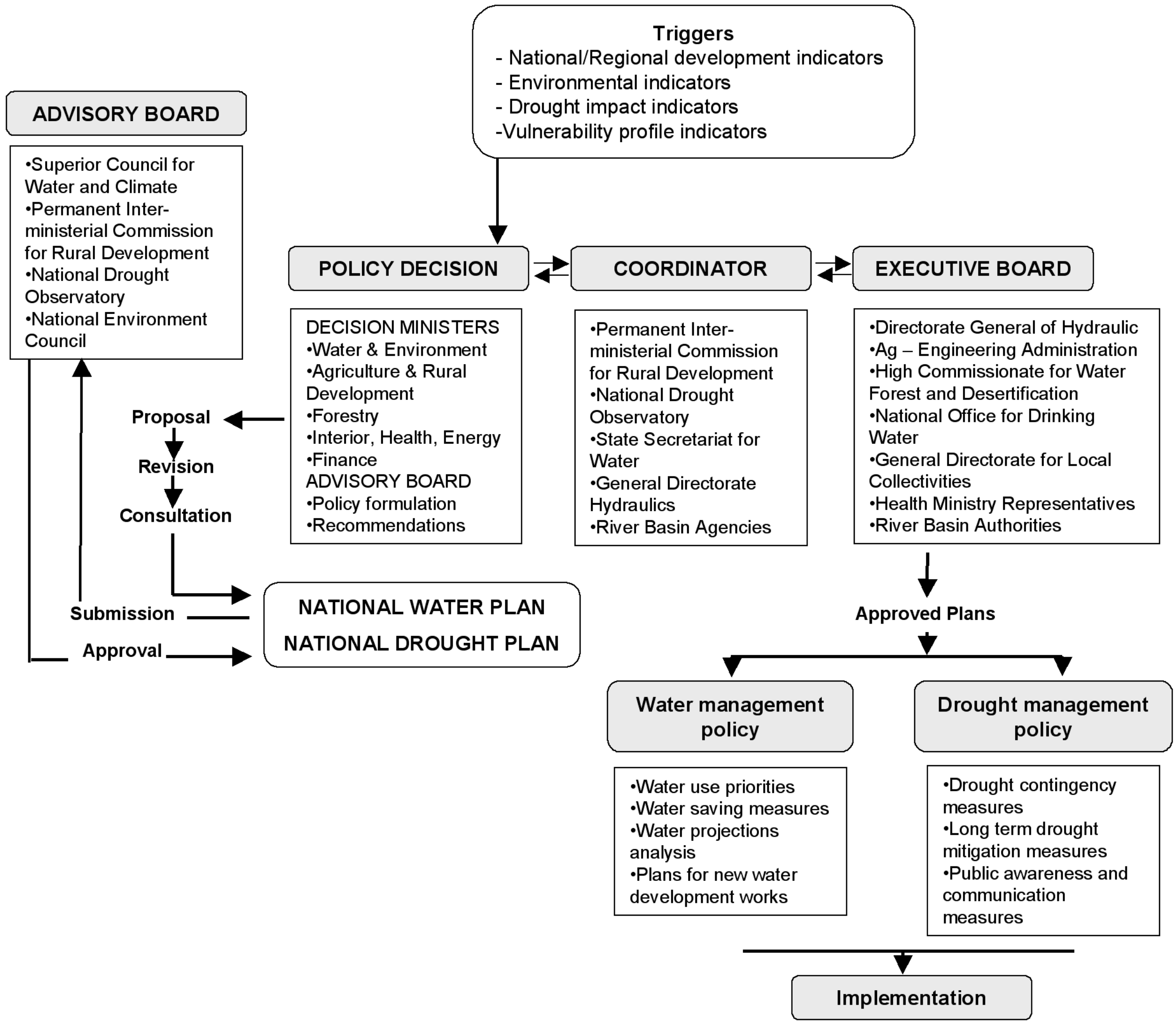


Fig. 18. Proactive responses in agricultural and hydrological drought in Morocco.

The National Drought Observatory

In 2001, the National Drought Observatory was created within the Ministry of Agriculture and Rural Development, and located on the campus of Institut Agronomique et Vétérinaire Hassan II (IAV), as a mean of building institutional capacity to cope with drought in Morocco.

The National Drought Observatory Center's specific objectives are to:

(i) Collect, analyze and deliver drought related information in a timely systematic manner.

(ii) Characterize drought and define reliable indicators that can provide early warning or emerging drought conditions.

(iii) Conduct vulnerability assessments to determine those sectors most at risk from the occurrence of drought.

(iv) Establish criteria for declaring drought and triggering mitigation and response activities.

(v) Ensure timely, accurate assessment of drought impacts.

(vi) Establish procedures to evaluate the effects and impacts of drought programs.

At the national level, the Observatory is managed by the Ministry of Agriculture and Rural Development, through a central management unit located at IAV Hassan II. In addition to the involvement of the central administrations of the Ministry, its regional structures are also involved in the proposed operational activities during implementation of the National Programme for Drought Mitigation. The Observatory has indeed to work with the Centre Royal de Télédetection Spatiale (Royal Centre for Remote Sensing), and has to develop links with the other ministerial structures and institutions, basically the National Meteorology Office and the Hydrology Administration (Water Department), the Department of Environment, the Department of Forestry, and the Ministry of Higher Education and Scientific Research through university centers. Other national partners may join the network as activities around drought management develop.

At the international level, the National Drought Observatory is supported by the US National Drought Mitigation Center, University of Nebraska, Lincoln, and by USDA. The Observatory has also organized a joint workshop with the US Corps of Engineers on the shared vision methodology for water management under drought conditions. Further developments of scientific links are being established with other institutions and centers. Since its creation in 2001, the Observatory has developed training programmes on proactive drought management approaches to meet the needs of national professionals and has organized an advanced course at IAV Rabat with Mediterranean Agronomic Institute of Zaragoza (IAMZ) on drought management strategies in the Mediterranean. On this occasion, the need to create a Mediterranean Network on Drought Preparedness was highlighted and discussed. This development led to the creation of the NEMEDCA Network with FAO, ICARDA, and CIHEAM / IAMZ. Of direct relevance to the MEDROPLAN project, the National Drought Observatory organized the Regional FAO Workshop on ''National Capacity Building for Drought Mitigation in the Near East Countries" which was held in Rabat, 1-5 November 2002, and where the latest developments on water management policies and drought preparedness issues in 14 countries of North Africa and the Middle East were presented and discussed.

Conclusions

The major lesson from the analysis of the previous situations is that drought is a structural of the Moroccan climate and that the fight against the drought cannot be improvised. It has on the contrary to be written down in a way perfectly integrated into the national strategies of water resources development and management. This is evident all the more as the hydrological context is fragile in consideration of the frequency of drought, the irregularity of the climate and the steady pressure exercised on water resources by more and more conflicting demands.

The consultative institutions in charge of advising the various line agencies and ministries regarding water and drought management do not have regulatory powers. They issue recommendations and approve plans. The regulatory functions over water utilities, in irrigation as well as in municipal water distribution, are usually mixed with operational duties as planning, project financing and supervision, and supervision of line agencies. The list of ministerial bodies involved in the sector shows very clearly the shortcomings of the actual setting, although improved by the consultative bodies.

In the current setting, stakeholders do not have always a proper say on water issues, except locally by the control over municipal water through the Local Authorities, which work under the supervision of the Ministry of Interior. However, slow change is taking place. This change will be supported because NGOs and civil society are more active in this field, and water user associations are gaining more autonomy in their dialogue with the administration.

The dispositions relative to the sensitization of the populations for water economy and on water resource use rules allowed easing in a significant way the effects of water shortage. However, the analysis a posteriori of the past management showed the lack of preparation of the country to face this kind of situation. It followed in certain cases a delay in the decision-taking to engage the necessary capacities for the drought management.

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Annex 1. Data and information systems

Summary of Institutions that collect, record, and process data that provide a representation of natural processes and socio-economic patterns related to drought in Morocco.

Category	Institutions	Type of data
Climate Water	DMN, Forestry, ORMVA, DPA, SCWC DGH, AGR, DPV, ONEP, SCWC, River Basin Agencies, Autonomous state-controlled companies, ME/Water	Meteorological Surface water, Groundwater, Water quality control Water use and allowances
Land	DAF, DPV, ANCFCT, CRTS, MI, DCL, ME	Land use, topography, land census, administrative and ecological zoning
Agriculture	MADR, DPAE, DPV, DE, AGR, CGDA, DEPAP, CNCA, MAMDA, ONICL, INRA, IAV, ENA, CRTS, ME,	Agricultural census, statistics (area, type of farms, labor, production, prices, export and import), Research and development activities
Forestry	CFLD, DDF, DREF, ENFI, IAV, ME	Forestry (areas, products, prices)
Socioeconomic	DPAE, MI, IAV, ENA, INRA,	Population, macroeconomic indicators, Universities and NGOs production costs
Energy & Mine	MEM, MC, ONE	Statistics by activity, energy consumption
Finance	MF	Statistics by activity, Studies reports, Outlook report

Annex 2. Potential impacts of drought

Summary of potential drought impacts in the Oum Er Rbia Basin based on responses of stakeholders. Impacts range from 0 (not important) to 5 (most important).

Impact	Oum Er Rbia Basin rank
ECONOMIC: WATER SUPPLY	
Additional cost of supplemental water infrastructures	1
Additional cost of water transport or transfer	1
Decrease in hydroelectric power generation	2
Decreased revenues of water supply firms	3
Increase in water tariffs	2
Increase in water treatment costs	3
Increased cost of ground water extraction	3
Reduced service quality	3
Other (please specify)	
ECONOMIC: AGRICULTURE	
Decrease in farm income	4
Decrease in land prices	2
Decrease in livestock feed quantity and quality	4
Decrease in rangeland and pasture production	4
Decrease of agricultural labour	4
Decreased crop production	4
Decreased crop quality	3
Decreased water in farm ponds for irrigation	4

Impact	Oum Er Rbia Basin rank
ECONOMIC: AGRICULTURE	
Increase in consumer credits in rural areas	1
Increase in crop imports	2
Increase in food prices	3
Increase in insects, pests, and crop diseases	4
Increase in livestock diseases	3
Increase of farm subsidies	3
Increased crop insurance premia	1
Increased soil erosion	4
Increased unemployment of the agricultural sector	5
Livestock production: water quality and quantity	3
Loss of farm income	4
Loss of income of industries dependent on agriculture	3
Losses in financial institutions related to agricultural activities (e.g., credit risks)	3
Revenue losses to state and local governments (from reduced tax base to farmers)	3
Other (please specify)	
ECONOMIC: FISHERIES	
Decrease production of fishery	0
Other (please specify)	
ECONOMIC: FORESTRY	
Decreased production of forests	2
Other (please specify)	
ECONOMIC: INDUSTRY	
Changes in the energy cost (e.g., due to changes in hydroelectric by oil)	0
Electric power unbalance (Increased energy demand and reduced supply)	2
Income loss of manufacturers and sellers of recreational equipment	0
Other (please specify)	
ENVIRONMENTAL	
Biodiversity loss in ecosystems associated with water	4
Biodiversity loss in land based ecosystems	2
Changes in estuarine areas (e.g., salinity levels)	2
Changes in the migration and concentration of animal species (loss of wildlife in some areas and too many species in others)	2
Decrease in reservoir and lake levels	4
Deterioration of visual and landscape quality (e.g., dust, vegetative cover, etc.)	2
Deterioration of air quality (e.g., dust, pollutants)	1
Ground water depletion and land subsidence	3
Increase erosion of soils by wind and water	2
Increase in diseases in animals (e.g., due to low quality of water or poor feed)	3
Increase in diseases in plants (e.g., due to low quality of water)	3
Increase in invasive weeds and algae	3
Increase in number and severity of fires	4
Increased stress to endangered species	3
Reduction of the wetland areas	2
Water quality effects (e.g., salt concentration, increased water temperature, pH, dissolved oxygen, turbidity)	2
Other (please specify)	

Impact	Oum Er Rbia Basin rank
SOCIAL	
Appearance of human health related problems (from water and air quality deteriorations)	2
Conflict appearance in management	3
Conflict appearance in media or science	3
Conflict appearance in political decisions	4
Conflict appearance in water use	5
Damage in cultural heritage sites	2
Danger to public safety from forest and range fires	3
Decrease in the visits to a recreational area	2
Decreased nutrition quality in subsistence farm areas	2
Deterioration of aesthetic values	2
Increase in the poverty level in rural areas	4
Increased migration to urban areas form agricultural areas	4
Public dissatisfaction with government regarding drought response	5
Other (please specify)	