

CLIMATIC HAZARDS, LAND USE CHANGE AND THEIR IMPACT ON WATER RESOURCES IN ARID AND SEMI-ARID MOROCCO THE CASE OF THE EAST AND SOUTH EAST

The Eastern and the South-Eastern parts of Morocco constitute two regions which present many common characters on several levels. Apart from some greenery "islands" of very limited extension favoured by height, the rest of this vast territory is rather homogeneous at the level of landscapes, which are characterized by considerable aridity. The ecosystems are fragile and sensitive to various changes, natural as well as anthropological. The important changes, especially those related to human activities, arose only during the twentieth century. If the vegetation cover and its edaphic support are the most affected by socio-spatial mutations, the water resources do not remain less perturbed.

Due to its orographic position and its geographic location, this zone suffers both from the weakness of rainfall contributions and from the severity of dry Saharan influences. Indeed, the atlantic and mediterranean air masses, which convey precipitation that have already lost their importance while crossing the atlasic-rifain barrier before arriving in expansion in this back country, which is generally a steppe area. They undergo new forced ascent only on some high and suitably exposed and aligned massifs. The decrease of rainfall quantity from the North southward and from west eastward is so stressed by the configuration of the relief imposed by the Rif - Middle Atlas - High Atlas barrier.

This situation is furthermore complicated by the seasonal and inter annual climatic irregularity. Several dry years can alternate with few relatively wet years. This climatic variability in intensity and frequency make dry periods succeed wet ones which influence, more or less directly the availability of water resources. During the last decades, the periods of strong drought have become strikingly more frequent. Therefore, the behaviour of groundwater, the regime of certain sources, and the river runoff are subject to important variability. Except in periods of flood, the main part of the current available water is provided by the runoff and the underflow of the main rivers and their tributaries, which are fed by sources. Most of these water resources are resurgences of water tables overflow. Actually, feeder and communication between these subterranean reservoirs are unknown in most cases.

The traditional economy of these regions is generally based on agro-pastoral activities which are extensive in rural areas and intensive in oasian environment. In forested areas, which are essentially mountainous, populations settled more or less according to the accessibility and availability of water resources. Most of the built up areas have derived from real oases. Those areas include cities which are rapidly expanding like Oujda, Guercif, El Aioun, Taourirt, Missouri, Errachidia ... The others have remained oases of sources or of *oueds* (streams), like Figuig, Bouanane, Beni Tajit, Boudenib, those of the middle course of Moulouya valley and those of the Ziz valley and its tributaries (Todgha, Gheris-Ferkla). The other cities and the urban areas which have arisen from other activities, like Nador, Berkane, Ahfir, Jerada, Tendrara and Bouarfa, have underwent important extensions.

The traditional agro-pastoral activities were strictly bound by water availability. Dry farming (*bour*) is often unpredictable. The irrigated cultures exploited stream water and sources gushing on slopes at the piedmont of permeable reliefs. Subterranean water was exploited for irrigation only in oases located at the South of the High Atlas range by means of digging *khettaras* (subterranean channels draining perched water tables) and of wells using *oughrou* or *chadouf*. Elsewhere, wells were used only to water livestock and to provide drinking and domestic water for populations.

This traditional system has been gradually changed by demographic growth and socio-spatial mutations of colonial and post-colonial time. At first, the appearance and the growth of cities, the development of urban life and the establishment of industrial activities became essential factors in the increasing need for water. Then, on the other hand, it was affected by the development of irrigated agriculture in modern perimeters, as well as in traditional ones.

Within the framework of its "policy of dams", the Government decided to build big dams in this back-country, formerly named "Useless Morocco" (*Maroc Inutile*) by the colonists. There were at first about two dams (Mechraâ Klila or Mohammed V, 1967 and Mechraâ Hommadi, 1956), in order to irrigate modern perimeters created in the lower course of Moulouya river. A third dam projected at the beginning of the fifties

was built later in 1998 (in a site named Loghress, then renamed Hassan II), upstream on Oued Za, the main tributary of Moulouya. The aim was to avoid floods on vast agricultural terraces downstream by regularization of the runoff, to decrease silting up of the two dams situated nearby downstream and to provide water for some cities.

Besides, in the Southeast, the Hassan Addakhil dam was completed in 1971 on Oued Ziz, upstream of Errachidia, but without the creation of a new irrigated perimeter. Nevertheless, the old palm groves of Tafilalt located downstream benefit from it by regular releases of water, thus protecting cultures against devastating floods and feeding underflows which constitute the main exploited water table.

In addition to an electric power-station (Mechraa Klila), important hydro-agricultural projects were carried out downstream of these dams, especially modern agricultural perimeters created in the lower course of Moulouya (Triffa in right bank, Bouareg Sabra and El Gareb in left bank).

If these achievements relieved in a sense the demographic weight in the already degraded surrounding mountains, human pressure remains still remarkable on traditional rural areas. Generally, the concern to improve incomes drove towards the intensification of agrarian, forestry and pastoral activities. The vegetation cover of forest and steppe areas has been widely weakened, and local water resources have begun to undergo overexploitation, far from government's great hydro-agricultural planning.

Well before the development of irrigated sectors, breeding and dry farming, which prevailed, had undergone important extensions. The traditional breeding based on "ecological" extensive nomadism turned in itinerant stalling, taking advantage of mechanical means of transport, the increasing number of watering places and cistern lorries. This large mobility of livestock annihilates vegetation, mellows or/and piles up soils, which reduces infiltration of water and increases water erosion, as well as eolian deflation. This evolution has reduced considerably the keeping back of underground water by means of decreased feeder of local water tables.

Besides, the various administrative divisions and the limitation of lands led to land appropriation, by more or less regular exploitation requiring settlement of nomad populations. Cultivation of soils in steppe and forest range lands became a way to appropriation. The income of this activity is mostly lower than that provided for livestock by the natural climax vegetation. The reduction of the pastoral space by these practices exposes the remaining areas to overgrazing. This situation evolves towards degradation of vegetation and soils on grazed lands as well as on the cultivated areas, then influence negatively the water balance. This evolution, which considerably reduces the coefficient of infiltration, thus consequently decreases feeding of water tables by limiting the soil's water retention.

During the 80s, the ancestral technique of construction of small dams on valleys increased with establishment of a government program. These small traditional seasonal reservoirs known under various names proliferated under the name of "*Barrages collinaires*" ("Hill dams"). They are sometimes really small low cost dams which provide some water for livestock and breeders, and even for irrigation. They also play a role in keeping back sediments, reducing thus silting up of great dams situated downstream; they also keep feeding local water tables. Besides, they engender microclimates around their small lakes which stretch according to rainfall.

In the urban environment, the consumption of water has increased in rapidly expanding cities and within industrial establishments (Oujda, Jerada, Nador, Berkane...). The advent of motor pumping which benefits first cities then agricultural areas.

If the process of urban development of certain cities consumed widely irrigated agricultural environment, including used water resources (sources) (Oujda - Sidi Yahya), the irrigated area has been regenerated by translation a little farther downstream (Bouchtat). But, on the other hand, the water balance is profoundly affected. This new agricultural extension uses groundwater by means of wells. The sources and urban houses' wells have been reclaimed by ceaseless lowering of piezometric level. This fact occurs with the overexploitation of the water tables supplying at the same time and in full extension the irrigated perimeter, urban areas and industrial units.

The cities affected by water shortages related to the overexploitation of local resources, complicated by the severe drought of the last decades, have decided to stock up water from distant areas, whereas farmers have replaced one after the other traditional individual wells with drillings, also individual and deeper and deeper. But, naturally, the geological structures do not allow in all cases easy access to underground water.

The rush towards pumping, private as well as public (collective), is widely changing agricultural development. Thus, in the North of the High Plateaux, the important intake of underground water for the coal

power station in Jerada has affected deeply the process of development, and the extension of the irrigated perimeter at Ain Beni Mathar, which was formerly irrigated by great sources. The weakened sources flow is being enhanced by motor pumping. Also, in the Taourirt - Oujda corridor, the recent increase of individual pumping stations upstream of Oued Qsob inevitably deprives water users downstream, where the drainage was perennial. For these downstream peasants, even wells become useless in period of prolonged drought, like the one that occurred in 1998, because of excessive intake made upstream.

In the South, another meaningful case is represented by the Todgha-Ferkla basin, where the available water is essentially conveyed by a little deep alluvial water table. The regime of piezometric level fluctuations is function of contributions of rivers and overflowing sources to runoff and underflow, besides rainfall and pumping intensity. The measurements of fluctuation and the observed facts are sometimes alarming, not only at the quantitative level, but also on the qualitative level because of presence of sectors with high risk of salinity.

During two consecutive years of severe drought which raged all over the country (1998-1999 / 1999-2000), the remarks recorded in various periods show important fluctuations of the groundwater level in the Todgha valley, which compromises the availability of water for a great number of peasants who share the same resource. This water shortage is not only due to drought, but also to the increasing number of wells throughout the whole valley. Only at the plain of Ghallil (downstream from Tinghir city), more than 600 wells are equipped with motor pumps, among which only 4 seem to be inexhaustible, at least when exploited with common powered individual motor-pumps, due to their privileged location upstream (Tisghiyt, Ghallil Oufella).

Downstream, up to the beginning of 60s, the water flowed on the surface along Tinjedad's road. Traditional perimeters of this sector underwent serious water shortage only in 1981, then 6 years after the creation of El Bour's perimeter situated a few kilometres upstream. This relatively recent perimeter has been in a crisis of water shortage for 6 years, therefore 16 years after the beginning of investments in the Ghallil plain.

These observations underline the impact of the ceaseless investments in irrigated agriculture and the uncontrolled pumping which ensue from. Water resources resulting of underflow of Todgha and overflow of the preafrikan furrow become more and more sensitive to drought due to increased number and intensity of intakes. Due to the lack of water, some investors have already abandoned their plots...

Another telling example is illustrated by the experience of Figuig, which is an oasis living important changes in land use and water resources. Reduction of agricultural space by successive seizures of the border lands of the Zousfana river have had significant consequences, especially in 1963 and in 1976. Numerous farmers emigrated, others tried to create new perimeters, but with highly saline water in some cases. Emigration was also a help in an agriculture in crisis by supplying important financing. But few projects are really profitable, whereas others are qualified as "sentimental", absorbing investments without real benefit.

This phenomenon contributed to a disproportionate increase of the price of water in the oasis because of speculation. From the beginning of the 60s, some wells have been dug, equipped and exploited for irrigation. But it is only in the middle of the 90s that a collective program of massive extension was launched (Plain of Tisserfine). Numerous wells are being used to irrigate new areas, but with enormous individual investments organized in cooperatives, the incomes of which are still uncertain.

In some places, the development of pumping has provoked the salinization of soils and water (Berkoukes) and has had a negative impact on the outputs from certain gushing sources (pseudo-*khetaras*) located near pumping stations. On the other hand, it contributes to the protection of the cultural and historical heritage of a beautiful palm grove, favours the desalination of certain soils victims of salinization, and reduces the price of water in the oasis.

In the North of Eastern Morocco, including the northerly part of the High Plateaux, demographic pressure was relieved by emigration towards urban areas among which some are really "big villages". A migratory movement towards Spain which began by the middle of the 80s is actually having an impact on departure areas. Sometimes the savings of these numerous labourers employed in the Spanish agriculture sector are invested in agriculture in their own country. This is a rush towards wells and motor-pumps to create irrigated perimeters on lands with a rather silviculture and pastoral vocation, but without any official framework. The investments which are in progress can threaten seriously water resources in traditional irrigated areas formerly supplied by sources.

Locally, some of these activities in progress are contribute to the intense degradation of vegetation and soils, which has already provoked water shortages by decrease of infiltration and increase of streaming (Debdou).

The freedom of individual or collective exploitation (cooperatives) of water resources, except the government's enterprises, can have grave consequences in the short and middle term. The absence of an official framework and rational management of this rare resource in this territory marked by strong aridity is a great gap which deserves a particular attention. Besides, the subsistence and the massive increase of traditional systems of irrigation maintain a wasting of enormous quantities of water.

Cities in fast growth throw back quantities of polluted water in streams through sewers or directly in water tables in districts without sewerage. A durable management of the water resources can be achieved by the modernisation and collectivisation of infrastructures, as well as the adoption of new techniques of irrigation, treatment and recycling, which can have a positive impact both on water conservation and on the incomes of investments engaged by the population in small hydraulic sectors. ◆

Contact:

Abderrahmane EL HARRADJI

Laboratoire de Géographie Physique

Département de Géographie, Faculté des Lettres et des Sciences Humaines

Université Mohammed Premier, B.P. 457, - 60000-Oujda, Maroc

E-mail: elharradji@lettres.univ-oujda.ac.ma

