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Analysis of the Water Management System in a Mountain Territory, the Case of the Nekor Watershed, Rif, Morocco

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Abstract

Integrated management has become an essential approach for sustainable water resource management. However, if the concept seems relevant, its concrete application at the local scale has yet to be undertaken, with all the difficulties related to the complexity underlying the issue. The Rif is characterized by the multiplication and interdependence of uses, the overlapping responsibilities between public and private actors, the superposition of sectoral regulations, which raises the following question: Is the current management of water resources in the Rif mountains suitable for a future constraining on several aspects: socio-economic and climatic? The general objective of this work is to analyze the current management of water resources scientifically, politically, institutionally and legally, to identify the innovations needed for sustainable management and adaptation to climate change in the Rif Mountains. The systemic approach allowed us to highlight and prioritize the structuring elements of water management in the Nekor basin and their interactions. The crossing of hydrological data with socio-economic data allowed us to have a global and multidisciplinary vision of both uses and water resources, and of all the components of the system's environment, the interdependencies influence the management system, despite the complexity accentuated by the lack of data. Indeed, it was difficult to identify the influence of each component. The current degradation of resources is only a reflection of a socio-cultural crisis that can only be remedied by a change in mentality, economic development, social equity and more solidarity between the city and rural communities.

Keywords

Water Governance, Rif, IWRM, Adaptation to Climate Change, Nekor

Watershed, Systemic Approach

1. Introduction

Water is a common resource in the natural environment and an essential element for life. Water, in all its forms, allows the maintenance of life and links the different components of the biosphere.

Since its independence, Morocco has made considerable efforts to mobilize the necessary water to the sectors of activity and populations. Thus, it has adapted since 1995, the law on water established the principle of balanced management of water resources in order to satisfy and reconcile the various uses of water while safeguarding natural balances [1]. However, the complexity of the relations between surface water and aquifers, as well as the diversity of points of view and interests (private and public), only very rarely allows a consensus to be reached that will make it possible to reconcile economic development, land use planning, sustainable management of water resources and the protection of natural environments.

Like the northern region of the Kingdom, the Rif occupies a strategic economic position. The anticipated economic and social growth will inevitably result in greater pressure on water resources. In addition, it will result in a clear vulnerability to climatic hazards. The Rif mountains are known for their natural fragility associated with inadequate forms of management leading to phenomena and forms of spectacular degradation. The mobilization of resources, including water, in this context can no longer meet the development requirements of the region, which requires anticipation to make water a factor of development instead of being a handicap to the development of the region [1].

The Rif is characterized by the multiplication and interdependence of uses, the overlapping of responsibilities between public and private actors, the overlapping of sectoral regulatory texts, which raises the following question: Is the current management of water resources in the Rif mountains suitable for a future constraining on several aspects: socio-economic and climatic?

The situation of water stress that the Rif would risk is related to climate change on the one hand and on the other hand to political constraints, land use policy, economic development policy, environmental policy and demographic order. In this case, it would be necessary to identify the obstacles to the proper application of laws, and to show to what extent the implementation of new environmental and territorial management policies and territorial management policies condition the availability of the resource. Indeed, the current inadequate and inconsistent management of the water resource would not be valid for a constrained future (climate change and socio-economic development).

The objective of this work is the analysis of water management in a mountain territory, the case of the Nekor watershed, Rif, Morocco, with the aim of contributing to the development of an IWRM model at the level of the Rif taking into account the local challenges of the region, and the proposal of measures to be taken, and actions to be undertaken in order to adapt the modes and means of resource management to the consequences of climate change, and this, within the framework of a sustainable management.

2. Methodological Approach

2.1. Study Site

The Nekor watershed covers an area of about 780 km^2 between the administrative boundaries of El Hoceima in the west and north, Taza in the south and Driouch in the east of the region. (**Figure 1**)

The climate is typically Mediterranean with a semi-arid trend: cold and wet in winter and hot and dry in summer. The average interannual rainfall of the basin is estimated at 340 mm. Rainfall is concentrated between October and May during certain cold front passages, but can sometimes occur in summer under the influence of the relief [2]. However, the basin is subject to significant flooding due to stormy, intense and irregular rainfall and an environment very favorable to runoff. The flow of the wadi is very intermittent since the annual number of floods of the Nekor is on average around 3 - 4 and does not exceed ten per year.

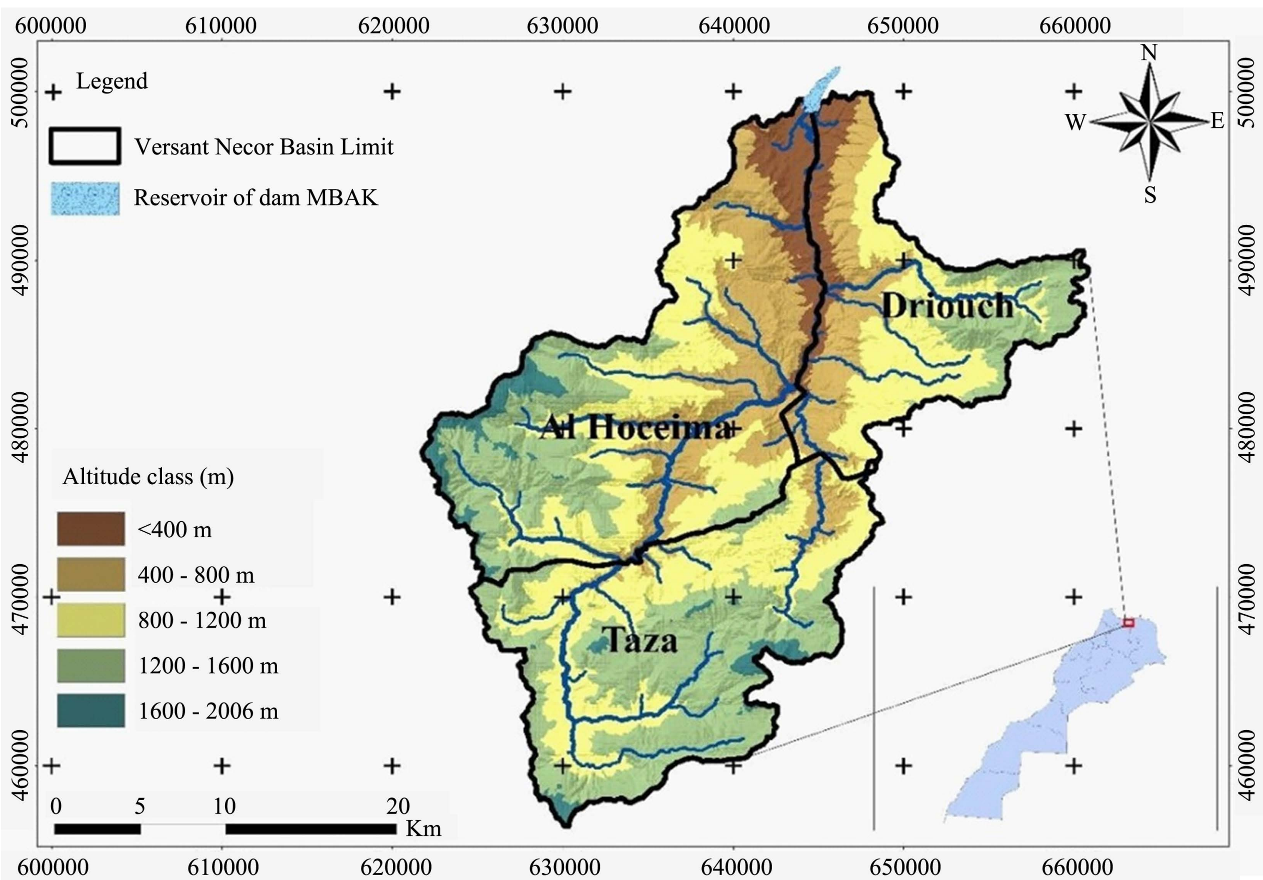

Figure 1. Geographic location of the Nekor watershed.

The average monthly temperatures vary between 7˚C (in January) and 28˚C (in August) in the whole basin but can go down to 0˚C in the mountain tops.

The dominant relief in Nekor is mountainous in nature. The average altitude exceeds 1500 m and the most pronounced relief is found in the east of the watershed at Azrou Akechou with 2006 m of altitude. The global index of slope is 20.7 m/Km in all the watershed, this index is higher in the banks of the left bank than for those of the right bank [3].

The soils are essentially made up of debris from the alteration of the substratum, are superficial and the organic matter content is low. In addition, some alluvial and terrace soils are distinguished. The texture of the soils varies from clayey to clayey-silt with some small cases of sandy-clay. This situation makes these substrates sensitive to erosion.

The dominant lithological formation in the Nekor watershed (marl-schist, shale), characterized by a high vulnerability to erosion, exposes it to significant degradation and soil loss.

2.2. The Mohamed Ben Abdelkarim El Khattabi Dam (MBAK)

The MBAK dam is located about 20 km southeast of the city of Al Hoceima. Its normal height is 140 m NGM. The initial capacity of its reservoir was 43.3 Mm^3 in 1981, the year of its commissioning, the last bathymetry carried out in 2013 shows that this capacity has fallen to 11.6 Mm^3. The average annual evaporation within the dam between 1990 and 2013 was 1285 mm. The structure provides irrigation for 4500 ha in the plain of Al Hoceima, drinking water supply and industrial, it is also used for the recharging of the water table from releases into the wadi, downstream of the reservoir [4].

With an average annual inflow of 33.7 Mm^3 and for an initial capacity of the reservoir of 43.3 Mm^3, the corresponding renewal rate is 77.8%. This dam has been the subject of several campaigns of bathymetric measurements to make a regular monitoring of the phenomenon of siltation within the reservoir given its important place in the development of irrigated culture in the region and drinking water supply. Runoff within the watershed constitutes only 14% [5].

The total siltation since the dam was commissioned until 2013 is about 31.7 Mm^3, a total loss that exceeds 73% of its initial capacity. In this regard, the PNABV was developed in 1996 making as the object of study 22 watersheds, classified according to a priority of intervention based on an economic criterion related to land losses due to erosion, both upstream and downstream. The Mohammed Ben Abdelkrim Al Khattabi dam (80% of the area at risk) is ranked 11th with a total loss of 316 million DH, of which 198 million DH is due to upstream losses and 118 million DH downstream [5].

2.3. Methodology

2.3.1. The Systems Approach and Water Resources Management

The complexity of the water management system and its uses is manifested in the relationships of the water management parameters at different spatiotemporal scales. To this end, the systemic approach seems to be the most suitable to understand the nature of these relationships.

This approach has been appropriate to study the issue of water management, especially since the water system is a transverse system with links to both the physical environment and the: social, represented by all the populations of the basin, economic, all the production and service activities in order to satisfy the users, technical, the transit or storage and distribution of water conditioned by the presence of a network of infrastructure, political-administrative, insofar as the legislative production and the political-administrative structuring of the territory influence the availability of the water resource for the various uses and also cultural when water has a certain symbolism that will dictate the behavior of the actors. In other words, a network of nested and/or interwoven systems interacts with each other.

2.3.2. Analysis of the "Stakeholder" Sub-System

Integrated management is conditioned by a multitude of parameters that characterize any management process, namely, knowledge, the scale of management, the integration of uses and stakeholders, communication and consultation, legal and institutional means of management and action structures. All of this is based on a set of actions and results aimed at the same objective: integrated water resources management.

An online questionnaire sent to the various potential stakeholders will make it possible to identify the power relationships between the various water stakeholders and to evaluate the decision-making process of the various categories of stakeholders as well as their roles in water management. (**Table 1**)

A value from 1 to 5 is assigned to each indicator according to the performance achieved by each actor. The sum of the points obtained, by indicator, offers a visibility of the strengths to be preserved and the weaknesses to be improved.

The actors questioned are:

- Stakeholders directly involved in IWRM: ABHL, ONEE and local authorities;
- Actors distributing water: ONEE for rural areas;
- The actors conserving water: the Regional Direction and the provincial services of Water and Forests, the Regional Water Service;
- The institutions and organizations managing the territory (Land Registry, Urban Agency, Local Authorities, etc.) and economic users of water for agricultural, tourist or industrial purposes;
- The actors carrying out the studies: private sector consultancy firms and scientific researchers in charge of carrying out the studies.

The objective of this evaluation is to report on the relevance, coherence and efficiency of the current system of actors. The proposed evaluation method highlights the expertise capacity of all the actors involved, closely or remotely, in water resources management, while emphasizing the diversity and the confrontation of the points of view of the actors with a view to further improving collective performance. The effectiveness of IWRM actions is conditioned by the organization of the competences of the different actors involved.

Table 1. Summary of indicators for the "stakeholders" subsystem.

Management process step	Indicator
Knowledge	State of knowledge of the actor on the resource used
	Setting up of evaluation tools
Scale of management	Territory of action and reflection to test the relevance of an integrated management
Integration of uses	Integrated use in the management
Integration of stakeholders	Feasibility of a partnership with other actors
	Knowledge of the use and involvement of the communes
	Number of agreements and partnerships between water stakeholders
Communication, consultation	Participation of the manager in a consultation process. Number of awareness and communication actions
Economy and financial means of management implementation	Type of financing contract (duration, number of financing), and consideration of other uses and the environment
	Integration of the use in the socio-economic system
Legal and institutional means	Degree of integration of regulations, their complexity and control
	Duration of the management plan or managerial time scale
Techniques	Techniques adapted for integrated management
Structure of actions	Institutional role: legitimacy, recognition, skills and responsibility of the manager
	Degree of representation on the territory of action
	Level of integration of the management method and ability to evolve

2.3.3. Analysis of the "Water Resource" Subsystem

The analysis of the "water resource" subsystem will be illustrated by a study of the problem of resource availability (inflow and storage) in the watershed, comparing it to needs (uses). This availability depends on the topographic, geological and climatic parameters of the catchment area, and on the development of the territory.

To do this, a descriptive diagnosis, quantitative and qualitative, water resources at the level of the basin of Nekor and the unit of Al Hoceima will be conducted. An assessment of the potential demand for water will also be realized to examine the potential of the watershed of Nekor in water resources.

2.3.4. Analysis of the "Uses" and "Development" Subsystems

The "uses" and "land use" subsystems, which are closely linked, are the subject of an analysis aimed at developing an IWRM model in the context of climate change. The water uses present in the Nekor watershed and the Al Hoceima unit correspond to the activities specific to a mountain territory:

- Scattered urbanization,
- Mountain agriculture, pastoralism,
- Tourism,
- Industry.

The diversity of uses depends on the territory, its economy and land use. The objective here is to highlight the needs and impacts of the main uses on water resources, and to highlight the lack of data and knowledge to evaluate them with a view to integrated management.

The diagnosis will be articulated in two parts. The presentation of the territory from a demographic and land use point of view introduces the water uses concentrated in the Nekor watershed based on an induction of uses at the Al Ho unit level. It highlights the interactions between uses and the environment on the one hand, and between uses themselves on the other.

3. Results

The choice of the watershed as the appropriate unit within which IWRM should take place is far from being free of constraints. First of all, from a natural point of view, there is the question of the size of the territory to be managed. The very notion of "river basin" implies taking into account the whole area drained by the river itself and its tributaries.

The effectiveness of water management depends on the factors on the ground. This has reinforced the choice of the Central Rif to analyze water management in a mountain territory in this study. This area has experienced a significant dynamic of change in the orientations and modes of water management.

This dynamic is illustrated essentially by three periods. The period of the Spanish protectorate that depleted the natural resources of the region by deforestation and mining, causing the acceleration of the process of erosion and land degradation. In a second place, came the post-independence period that gave more importance to agricultural and rural development ordered by the intervention of the state. This period saw the disengagement of the population from the technical hydro-agricultural orientation, for social and cultural reasons (Semi-directive interview with the director of the Agro-Concept research office, 2021). The interest in hydro-agricultural orientations has declined with the succession of drought periods (1980) and will be further absorbed by the reorientation towards a policy of supply management to satisfy demand. This demand is essentially translated by the progression of the needs in drinking water, industrial and tourist.

The retrospective and current diagnoses have well illustrated the totality of the uses and developments as well as the strong dynamics of the Rif mountain territory. By highlighting the uses and developments of the province of Al Hoceima which contains more than half of the population of the Nekor basin, the supply of drinking water relied on the dam Mohamed Ben Abdelkrim Al Khattabi since its commissioning in 1981 and for the irrigation of the plain of Al Hoceima at the time (4500 ha), so this dam accompanied the modes of water management in this province until its total silting currently. This silting was the turning point for managers to change their thinking and think about dismantling the reservoir and building another on the Rhis wadi to ensure the same functionality.

3.1. Analysis of the "Water Resource" Subsystem

The "water resource" subsystem involves the evaluation of all the water resources of the watershed, given by the hydrological balance. The input variables are precipitation. The output variables are the flows at the outlet of the surface basins and aquifers. The quantitative, qualitative and temporal differential is linked to several regulating functions such as evapotranspiration, retention and underground storage. These functions integrate the climatic characteristics, the bio-soil cover, the altitude, the physiognomy of the reliefs and their geological characteristics.

3.1.1. Climate

The climatic conditions of the watershed play a crucial role in the hydrological behavior of the rivers [6]. Rainfall is the essential factor, with its total annual height determining river abundance; its monthly and seasonal distribution directly influencing hydrological regimes, and its daily totals and especially the showers that generate floods.

The Nekor watershed is located in a Mediterranean area of semi-arid climate with an average of two seasons to be distinguished. A winter season that starts from October and ends in May and receives the maximum rainfall. A summer season with dry and hot climate is from May to September.

The precipitation, which is by far the most important, acts directly in the rainfall supply of the Nekor flow. The basic data we use are the rainfall series of the stations of Al Hoceima, Nador and Taza from 1980 to 2020. Also, the atmospheric temperatures of the basin will be sketched, while highlighting the importance of the dry season, and thus the of the dry season, and thus the determining effect of evapotranspiration, an essential parameter in the runoff deficit.

The climate is characterized by intense and irregular stormy precipitations which give rise to floods which, according to their importance, can be generalized to the whole catchment area or limited to one of its sub-catchment areas. These showers generally accompany in winter certain passages of cold front or can occur in summer under the influence of the relief. The number of floods observed in the Nekor watershed rarely exceeds four per year.

The observation of the annual precipitation curves has highlighted the trends in the Nekor basin towards the increasingly recurrent occurrence of droughts, random variations in precipitation, and trends towards an overall decrease in the amount of rain received.

At the monthly level, there are general trends towards an increase in precipitation at the beginning of the hydrological year (September, October and November) and a decrease in the middle (January and February) and end of the year, thus a decline in spring precipitation and a slight increase in August.

Temperature is the second key parameter in the climate analysis. In the Nekor watershed, the analysis of temperatures between 1980 and 2020 concluded that there was a basin-wide average warming during this period.

Daily variations in precipitation and potential and actual evapotranspiration highlight all the changes that affect the water balance over the 365-day period of the year.

According to the results obtained by Salhi [7], the deficit period extends over a duration of 294 (the equivalent of 9 and ¾ months) distributed as follows:

- 91 days from the first of September until the beginning of December;
- 13 days from mid-December to the end of the same month;
- 6 days in the second week of January;
- 7 days from the second week of February;
- 5 days from the end of February to the beginning of March;
- 172 days (equivalent to about 5.5 months) from mid-March to the end of August.

The surplus period extends over 36 days spread over 5 phases, 10 days distributed between the first week of December and the last three days of the same month; 15 days spread over the middle and end of January; 8 days in mid-February, and 3 days in the first week of March.

The use of the water reserve is carried out over the period of 4 to 10 days following the various surplus periods; this is a total of 35 days [7].

3.1.2. Evaporation from the SMBK Dam

The maximum value of evaporation recorded was 4.5 Mm^3 of water during the year 1995/1996, while the minimum value is around 2.44 million/m^3 measured in 2005/2006. The average annual evaporation is 3.52 million/m^3 for the Mohamed Ben Abdelkrim Al Khattabi dam which has a total capacity of 43.3 million/m^3, an average annual loss of 8.2% of the total capacity.

3.1.3. Hydrography

Within the watershed, the course of the Nekor is divided according to Lahlou [3] into three sections. An upstream section represented by 2 wadis, the Khemis and the Barart oriented E-W, they take their sources on the slopes of the Azrou-Akechar massif, the beds are wide, anastomosing and the flow is permanent. Their tributaries are on the other hand narrow and recessed. A central section located north of Ajdir, downstream of the confluence of the two previous wadis, it includes the M'Baiou oriented South-North, its course is engaged in deep gorges thus taking the appearance of a mountain river. A downstream section: in this one the basin of Nékor is oriented SW-NE, it receives on its left: the Timerzga, the Malou, the Chekrane, the Imezrai, the Mnoud and the Souffoula. They are wadis with wide channel. They are supplied with water only irregularly. On its right bank, the hydrographic network is mainly constituted by the Sidi Aissa, which takes its source in the limestone massif of Azrou-Akechr, its regime is permanent and often torrential. Further downstream, several tributary wadis of the Nekor basin are present and are fed only temporarily. (**Figure 2**)

3.1.4. Surface Waters

The rivers of the Rifa area can be characterized by their torrential regime and the importance of their specific daily flood flows. In general, they have low or no low-water flows, except when part of their catchment area is located in limestone country, which causes a delayed flow, sometimes not negligible. In the other cases, the hydrological regime is explained by the clear predominance of clay, marl or shale facies in the watersheds, combined with steep slopes.

In relation to the impermeable clay formations, which constitute the bulk of the geological foundation of the Nekor watershed, water is rapidly conveyed northward by the main wadi of Nekor (low water flow of 1000 l/s) [8].

This watercourse is characterized mainly by an area at the mouth of the order of 960 Km^2 in addition to a length of 70 Km.

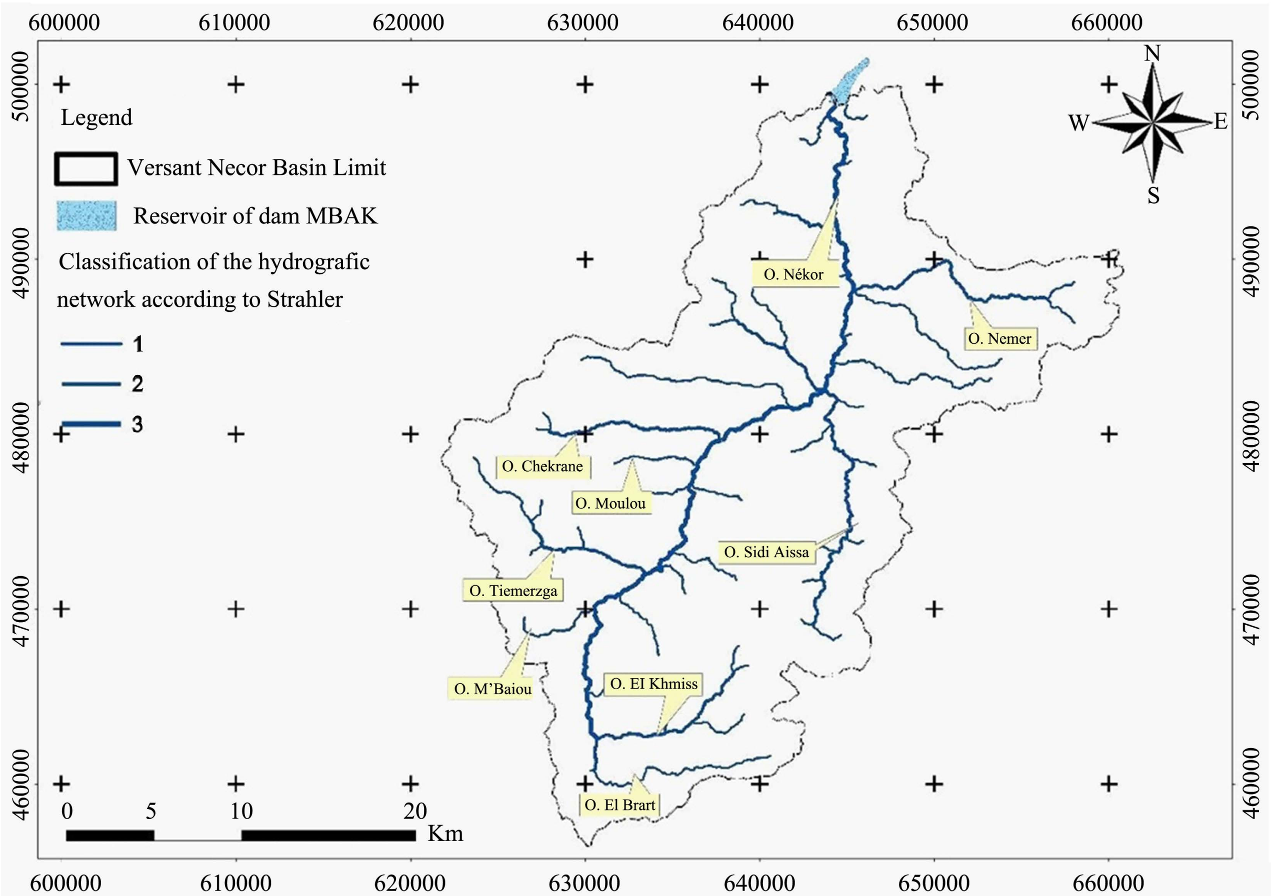

Figure 2. Map of the Nekor basin hydrographic network.

The surface waters of the dams Mohammed Ben Abdelkrim Al Khattabi (MBAK), on the wadi Nekor are controlled, both by the Services of ONEE-Branch Water, as well as by the Agency of Loukkos.

The chemical analyses carried out show that the waters of the Nekor wadi are more loaded with dissolved salts. The waters of the Nekor are of the sulphate-chloride sodium type. The dry residues vary from 1.2 to 2 g/l. The relatively excessive salinity of the MBAK dam is caused by the Triassic evaporite formations (saline gypsum and pelites), which outcrop extensively upstream of the Nekor wadi [8].

Most of the inflow is recorded in the form of floods, due to the torrential hydrological regimes of the basin courses.

3.1.5. Groundwater

The water table that dominates the area is the Rhiss-Nékor water table. With an area of 130 km^2, this groundwater is the main groundwater of the region, it has an average thickness of about 240 m. It is characterized by its easy exploitation and its vulnerability to pollution.

In the whole lower part of the Rhiss-Nékor plain, the water table is less than 5 m deep. The latter increases rapidly towards the South-East and towards the East, exceeding well over 50 m. The areas where the water table is less than 20 m deep total an area of about 55 km^2. At the very south of the plain, the depths decrease again in relation to a rise in the impermeable substratum and the presence of the El Khattabi dam. Seasonal fluctuations can be estimated between 1 and 2 m.

The water table is fed by the infiltration of rainwater, the return of irrigation water from the Mohammed Ben Abdelkrim El Khattabi dam and the infiltration of water from the Rhis, Nékor and other chaabats wadis.

The analysis of piezometric fluctuations of the different control points of the Rhis-Nekor water table shows, that after the brutal transitional state, which was influenced mainly by the drought and by the works of the Mohammed Ben Abdelkrim El Khattabi Dam, the water table reached, in 1982, a bottom state from which it stopped falling and began to fluctuate according to the new distribution of inputs [8].

The groundwater is exploited through withdrawals for irrigation and drinking water supply. Some of the groundwater is lost to evaporation in the downstream portion. The rest of the resource is lost to the sea.

3.2. Analysis of the "Uses" and "Development" Subsystems

The subsystems "uses" and "land use", which are closely linked, are the subject of this section.

The diversity of uses depends on the territory, its economy and its land use. The differences in economic support play a direct role on the mode of water use and on the management modes.

Thus, the "development" subsystem determines both the uses and the exploitation capacity of the available resources. The parameters that define the exploitation capacities relate to the infrastructures and networks: the storage capacity of the high altitude reservoirs, the flow of the captured sources, the efficiency rate of the AEP networks, the treatment plants, the dams…

Each use implies one or several actions on the resource: water abstraction actions, artificialization actions aiming at protecting uses (hydraulic or stabilization works…), discharges, or heavy developments to store water (dam, high altitude reservoir). Other actions can have an indirect impact via the modification of the occupation or the use of the soils of the catchment area

Other actions can have an indirect impact via the modification of the occupation or the use of the soils of the catchment area: modification of the cultivation practices, agricultural drainage, sealing of the soils…

The study of the actions associated with each use highlights strong links between the "uses" and "development" sub-systems.

3.2.1. Demography and Economic Activities

The population of the watershed has been estimated at 98,868 inhabitants, 51% of which are in the province of Al Hoceima, 28% in the province of Driouch and 21% in the province of Taza. Based on the last general census of 2014, these inhabitants represent 19,946 households, with an average size of 6.4 persons per household. The Nekor watershed is characterized by a high population density which is about 126.75 hab./Km^2 and far exceeds the national average which is only 37 hab./Km^2. This high density in a rural environment results in a strong pressure on the water resource from a quantitative (withdrawals) and qualitative (degradation of water quality) point of view.

3.2.2. Land Use

In the Nekor watershed, the forest is poorly represented due to climatic, biophysical and anthropozoic conditions. It still represents 5% of the total area of the watershed, occupied either by degraded shrub formations (2%) based on lentisk, Thuja and holm oak which constitute the natural vegetation at high altitude, or by reforestation (3%) based on Aleppo pine (*Pinus halepensis*), maritime pine (*Pinus pinaster*), *Acacia cyanophyla*, and *Cedrus atlantica* as an experiment.

Thus, 50% of the land is not cultivated and is covered by degraded vegetation not shrubby, serving as a range on which depends an extensive livestock consisting of sheep about 63.

These are used for the production of milk for self-consumption and are linked to the cultivated areas where half of their food needs are met.

Despite soil conditions and relief not very favorable to cultivation, 45% of the total area of the watershed is cultivated land of which 2% with traditional irrigation and 8.5% with predominantly arboriculture, the rest devoted to annual crops, including barley which is the main crop with 80% of the cultivated area. (**Figure 3**)

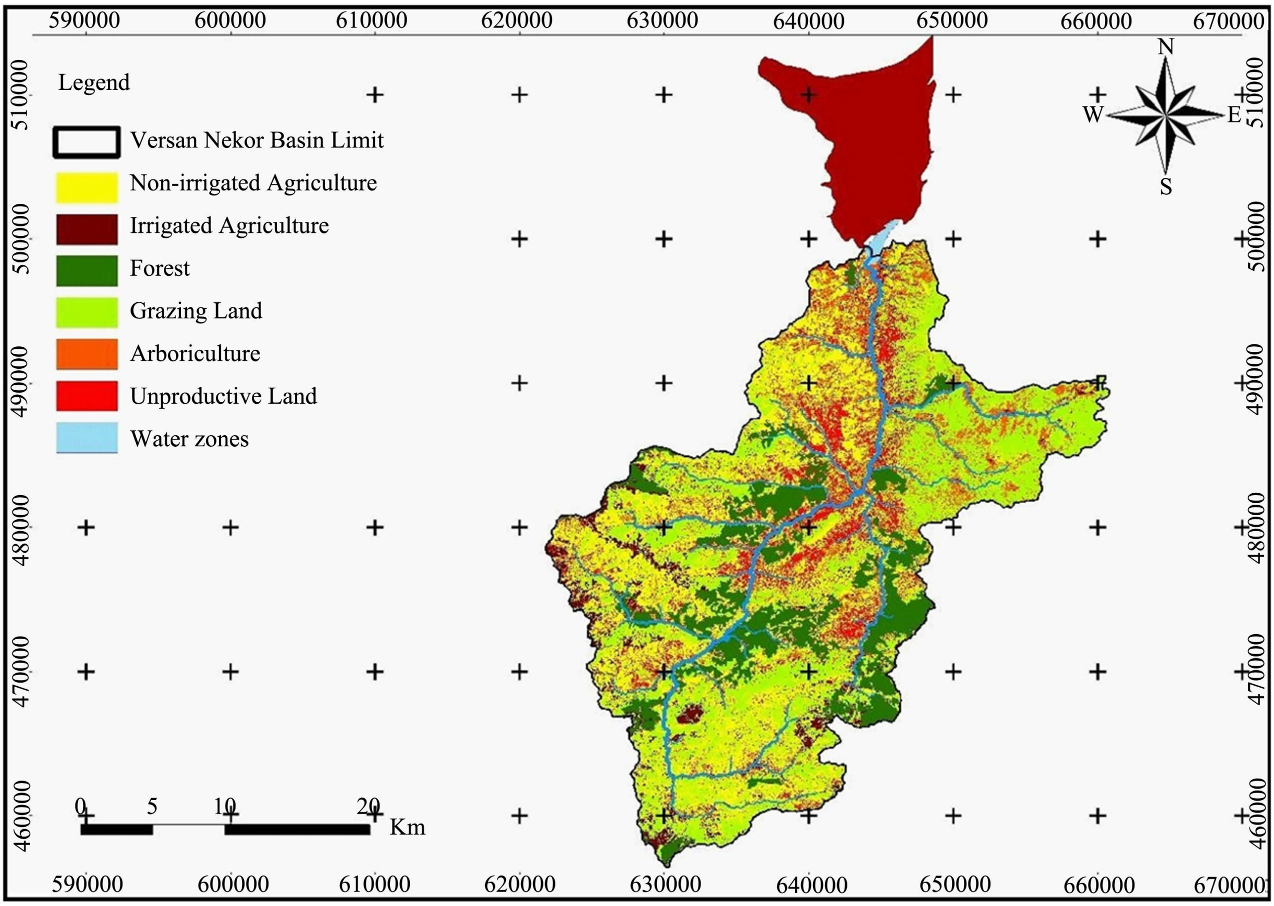

Figure 3. Current land use map of the Nekor basin.

In the study area, there are two main types of water resource use. The use for the production of drinking and industrial water is the most priority and the use for the development of irrigation.

Currently the supply of drinking water to the unit of Al Hoceima is essentially provided by the Sidi Mohammed Ben Abdelkrim El Khattabi Dam (SMBK Dam). The raw water of the dam is treated at the treatment plant of Al Hoceima whose nominal production capacity is 405 l/s of treated water with an increasing trend of withdrawal during the 1982-2016 period. This trend contributes in a direct way to its depletion.

With the silting of the SMBK dam, the current conventional water resources are insufficient to ensure the supply of drinking water in the study area. The resource to be released, to satisfy water needs by 2040, will have to provide an average complementary flow of about 388 l/s.

The catchment area of Oued Rhiss consists of two boreholes and two wells with an overall flow of 135 l/s. The Nékor catchment field, commissioned in July 2007, consists of three boreholes equipped for a total flow of 160 l/s.

The water treated at the treatment plant and/or collected by the wells and boreholes operated are sent to the municipalities, centers and douars of the province through the regional conveyance of Al Hoceima: This conveyance supplies the city of Al Hoceima, the municipalities of Bni Bouayach and Imzourene, the centers of Sidi Bouafif, Ajdir, Azghar, Izemmouren, Ait Kamra, Rouadi, Snada, Bni Boufrah, Cala Iris - Torres and Bni Guemil. Many douars near these centers are supplied or planned to be supplied from this water supply. The existing situation of AEP has been reinforced by the desalination plant of Al-Hoceima, commissioned in December 2019.

The fact that the SMBAK dam is experiencing significant silting (about 1 Mm^3/year) which could deprive the station of the necessary raw water treatment. Thus, the Directorate of Hydraulic Development (DAH) has scheduled the construction of a large dam on the Oued Rhiss which will ensure, among other things, the supply of raw water to the treatment plant (ST).

The balance sheet Needs-Production Capacity has shown that with the realization of the desalination plant of 200 l/s, the peak water needs will be met beyond 2035. That is to say that the flow of 405 l/s of the current ST is sufficient.

It is noted that the demographic growth is often accompanied by an increase in the needs for the resource.

3.2.3. Irrigation

The Rhiss-Nékor perimeter of the Al Hoceima plain is developed over an area of 5715 ha. The water supply is provided by water diverted from the Rhiss wadi and water regulated by the M.B.A El Khattabi dam on the Nekor wadi. However, due to the importance of solid inputs (1 Mm^3/year on average), which have resulted in a reduction of the capacity of the dam to only 20 Mm^3, and the development of the demand for drinking water in the city of Al Hoceima; the irrigation of the perimeter can no longer be ensured in the long term by the dam. Currently, only 6 Mm^3 are released annually for the irrigation needs of the Nekor perimeter. In the long term and with the rate of silting observed, the irrigation of the Nekor perimeter from the dam will be sacrificed to the advantage of securing the supply to the city of Al Hoceima.

The Rhiss-Nékor perimeter has suffered since its realization of a total chronic water deficit which concerns about 2/3 of the equipped area, due to the accelerated silting of the SMBK dam and the reduction of the contributions to the dam since the eighties. The master plan had provided to overcome this deficit the realization of drillings in the Rhiss-Nékor aquifer of a maximum volume of 10 Mm^3/year for the benefit of irrigation and the commissioning in 2000 of the Ifassiyène dam on the Rhiss wadi to ensure the sustainability of irrigation in the Rhiss-Nékor areas.

3.2.4. Summary of Water Uses

It emerges that AEPI consumes 10% of the total withdrawals in the current situation, with a portion of 90% used for irrigation. 82% of the AEPI volume consumed comes from surface water and 18% from groundwater.

By 2040, if all the irrigation development projects are retained, AEPI will consume 11% of the withdrawals, 85% of which will come from surface water and 15% from groundwater. In the case where the development projects are not retained, the abstractions of AEP will constitute approximately 40% of the total abstractions.

3.2.5. Diagnosis of the Developments Carried out or in Progress

The developments that can contribute to the reinforcement of the water resource of AL HOCEIMA system are:

- Realization of the Rhis dam on the Rhis wadi
- Realization of the Ifassiyène dam on the Rhis wadi
- Desalination of sea water or desalination of groundwater.
- Development of new underground resources.
- Maintenance of the SMBK dam.

The site of the dam on the wadi Rhiss, upstream of the Ifassiyène site, is located in the province of Al Hoceima, about 23 km from the mouth. The main purpose of this dam is to supply drinking water and industrial water to the city of Al Hoceima and neighboring centers, it must also ensure the irrigation of perimeters located downstream.

The Ifassiyène dam is planned to supply drinking water to the city of Al Hoceima and to support the irrigation of the Rhis-Nekor perimeter; it will be compared to the desalination of sea water and to the desalination of the Rhis-Nekor water table. The Ifassiyène dam on the Oued Rhis has been the subject of a detailed preliminary design study. The studied project is a roller compacted concrete dam with a height on foundation of 95 m and a storage capacity at the level of the normal reservoir of 150 Mm^3. The natural inflow to the dam is 35.6 Mm^3/year.

An additional withdrawal of 150 l/s from the water table is possible, especially in the central part of the Aït Moussa or Amar area, in the Imzouren region, where the water table is powerful and productive, and more particularly in the sector located on either side of the Nékor wadi, over a width of 1 km (a strip characterized by high transmissivities, exceeding 2102 m^2/s). The productivity of the structures in this area should be particularly important (several tens of l/s per structure). It is worth mentioning the existence in this area of two very productive boreholes not yet equipped and which can serve to strengthen the water supply of the city of Al Hoceima.

This additional withdrawal should be preceded by an update of the terms of the balance and a specific modeling study to simulate the impact (in space and time) of these pumping on the levels and quality of the water table.

If these studies confirm the possibility of drawing off this additional flow, it should be done gradually and should be accompanied by regular monitoring of the levels and quality of the water table, particularly in the vicinity of these withdrawals and along the coastal edge of the water table, to monitor the possible advance of marine waters.

It would also be interesting to study the feasibility of artificial recharge of the aquifer from leakage water and releases from the Abdel Krim Al Khattabi dam into the Wadi Nekor.

The removal of the SMBK dam can be very interesting in the medium term insofar as it would allow to postpone the deadlines of realization of the most expensive solutions (realization of the Ifassiyène or Nékor dam or the desalination of sea water). It consists in providing for periodic cleaning of the dam and reduction of its leaks.

In the case of the SMBAK dam, there will be no problem with the deposit of silt since it can be deposited immediately downstream and then carried away by the flows when the gates are opened during floods.

3.2.6. Interactions between Water Uses and Their Impacts on the Resource

Several relationships between different uses that depend on the nature of the action exercised on the resources and the spatial and temporal dimensions of the use.

Between uses competing for resources, concentrated in space and time, such as water supply and tourism;

Between "polluting" uses located upstream of "taking" uses, such as pastoralism in the protection areas of drinking water sources. In return, the regulations can constrain the practice of the "polluting" use;

Between storage facilities and recreational activities because of the artificialization of the watercourse and the instream flow. (Table 2)

3.3. Analysis of the "Actors" Subsystem

3.3.1. Summary of the Survey Results

Assigning scores to each indicator allows us to compare the management of each stakeholder and to highlight the variability in the levels of contribution of different stakeholders to the implementation of an integrated management system.

Stakeholders with a low contribution to IWRM are those with the lowest scores. For example, water users (industry with 28 pts and tourism with 34 pts) are the actors with the lowest score, which is synonymous with their low contribution to IWRM in the Nekor basin. It should be noted that the 37 points collected by the Water Department of the Regional Directorate of Equipment are due to the gradual transfer of its missions to ABHL.

ABHL has the highest score of all water stakeholders (61 points), followed closely by the Department of Water and Forests with 58 points and the scientists with 63 points. These actors are now considered the most involved in integrated management. However, water and forestry managers are victims of a lack of recognition by direct actors who compartmentalize them into the sole mission of forest management, and are not identified as direct water actors.

Similarly, the institutional and financial systems put in place do not recognize the role of the forest on the quality of water resources. The regulatory system does not involve them upstream in the elaboration of decrees concerning source protection perimeters.

The radars illustrate the degree of satisfaction of the 17 variables for evaluating

Table 2. Water uses and induced actions on resources by sector of activity in the Al Hoceima system.

Activities	Uses	Actions on resources
Agro-pastoralism	Livestock	Surface water withdrawals (drinking and washing water) and diffuse discharges (animal waste)
	Culture	Surface and groundwater withdrawals (irrigation) and diffuse discharges as well as soil transformations.
	Agri-food	✓ Water withdrawal ✓ Direct industrial or diffuse discharge
Industry	Mechanics, chemistry	✓ Direct withdrawal from the water table or the AEP network ✓ Direct and diffuse discharge (oil)
	Trade, crafts	✓ Direct withdrawal from the water table or the AEP network ✓ Direct discharge
	Wood industry	✓ Direct withdrawal from the water table or the AEP network ✓ Direct discharge
Urbanization, infrastructure	Urbanization	✓ Artificialization (weir, dikes, riprap) ✓ Soil transformation
	Network, infrastructure	✓ Artificialization, development ✓ Soil transformation (sealing)
	Sanitation	✓ Development, direct and diffuse discharges (stormwater)
	Drinking water (AEP)	✓ Development ✓ Gravity or groundwater withdrawals
Fishing	Fish farming	✓ Water withdrawals ✓ Diversion
Tourism	Network, infrastructure	✓ Development ✓ Soil transformation (impermeability)
	Water supply (seasonal)	✓ Development ✓ Gravity or groundwater withdrawal
	Sanitation (seasonal)	✓ Development ✓ Direct and diffuse discharges (stormwater)

the management system of the water stakeholders, and highlight the water management methods of the different stakeholders.

The Loukkos Water Basin Agency seems to be the most capable of integrated management (61 pts). It has the skills required to draw up the integrated water resources development plan, which is spread over 10 years, to ensure consultation and maintain contact with the various stakeholders in water management and thus to have an overall view of all uses throughout the basin. However, several limitations represent obstacles to the ABHL, which can be summarized as follows: the extent of the territory of action over the entire northern part of the Kingdom, thus making relations with the stakeholders sometimes rather difficult; the lack of control over land, which is essentially explained by the difficulties that characterize the delimitation of the public hydraulic domain; the low involvement of the communes, etc.

The current consultation process does not include the stakeholders who could potentially be involved in the implementation of IWRM. Thus, stakeholders from tourism, industry, representatives of water consumers (ordinary citizens), etc. are excluded or under-represented.

3.3.2. Diagnosis of the Strengths and Weaknesses of Management Systems for Each Stakeholder

See Table 3.

4. Discussion

The scarcity of water resources and the decrease in regulated volumes, the continuous increase in needs, climatic hazards (drought, flooding), the overexploitation of groundwater, the degradation of water quality and pollution, the low value of mobilized water, The loss of dam capacity due to silting, the increasingly high cost of mobilizing new resources (such as desalination) and the spatial disparities in the distribution of water resources are all factors that make water management more difficult.

The implementation of IWRM is of great interest for the simple reason that it contributes to the resolution of problems related to water and associated ecosystems (Guide developed by the Quebec Ministry of the Environment, 2004). This management method, based on the participatory approach, allows stakeholders to merge their efforts on the real problems of water and associated ecosystems, to identify the issues and to prioritize the main constraints.

IWRM at the Nekor basin level has limitations. Management requires collective and heterogeneous participation, involving multiple stakeholders who may clash due to their mutual interests. However, several political, regulatory, social, technical and financial constraints can distort, delay or stop any IWRM project.

The current water management system is far from reaching an integrated regime for several reasons: a regulatory corpus in silos, spatial and territorial concentration of water uses, and the absence of the notion of common good among water users, which explains, in a way, the wasteful consumption and the disengagement of the population in the management of water resources

Climatic, topographical and geological parameters are also determining factors in the hydrological balance and influence the water management system, which depends on hydrology but also on the cost and price of water.

The effectiveness of the law to protect the environment (a relatively new discipline) is far from being a reality: complexity and slowness of the procedures relating to the elaboration of the texts, the study and approval of the laws, the delay recorded in the promulgation of the decrees of application, non-application, insufficient implementation, inappropriate and insufficiently powerful institutions, preferences granted to soft methods, often extra-judicial, unilateral action of the Administration…

Table 3. Diagnosis of the strengths and weaknesses of management systems for each stakeholder.

Acteurs	Forces	Faiblesses
ABHL	- Global vision of the uses on a hydrographic scale - Consultation with the main actors and users of water - Monitoring of measurement networks - Competences and financial autonomy - Planning over 10 years and prospective vision - Integrated approach taking into account technical, economic, financial and institutional aspects	- Distance from the action territory - Discrepancies between river basins, water bodies and territorial issues - Sectoral financing of water policy - A somewhat limited consultation process - Lack of administrative autonomy since the Ministry in charge often interferes in its work - The agency's action sometimes exceeds its legal missions, particularly in the management of hydraulic works - No data on the environment to evaluate the impact of water withdrawals - Few awareness actions
ONEE	- Technical expertise	- Lack of legislation specific to concessions - Severity of the public domain regime - Insufficient legal instruments - Sectoral strategies and lack of convergence - Lack of regulatory bodies and supervisory entities - Lack of consultation and coordination with the communes and the services concerned when carrying out studies - Inequitable distribution of water resources and mobilization of water at high prices in rural areas due to the uneven topography and scattered nature of the habitat - Low rate of adherence of the local population to the water supply program
Services de l'État en charge des politiques à l'eau	- Data and monitoring networks - Relations with all water stakeholders and users ensured by regional and local departments - Strong involvement in the consultation phases - Evolution of practices towards more integration	- Gaps in data homogenization and collection - Failure of the water police - Insufficient funding - Lack of communication, awareness-raising actions
Département des Eaux et Forêts et Gestionnaire s forestiers	- Actor in the field - Long-term planning - Management oriented towards the valorisation of non-market functions, hence a favourable context for taking water into consideration - Significant role in the local economy - Technical expertise in the development of water bodies and the fight against erosion	- No skills to manage the forest in the perimeters of the springs - Multifunctional management applied with difficulty due to lack of means - Lack of involvement of elected officials in the management of their forests and little contact with water stakeholders - Non-adapted sectoral financing. - Difficulties during the delimitation of the forest estate - Lack of consultation with ABHL - Strained relations with local authorities and forest users

Continued

Région	- Suitable structure to coordinate water management - Strong links with the LCs thanks to its financial support	- Lack of water management expertise
Collectivités territoriales	- Relations with all stakeholders and users	- No control over land resources - Planning reduced to the electoral mandate - Lack of technical and financial means - Volume of wastewater discharged without pre-treatment into the receiving environment (wadi or sea) not quantified
Agriculteurs et department agricole	- Multiple socio-economic and environmental functions - Practice of PI and localized irrigation - Awareness of water rationalization	- Little data on farmers' resources, consumption and discharges - Little relationship with other water stakeholders - Poorly targeted sectoral funding
Département, Institutionne ls et Représentan ts du Tourisme	- Policy of diversification of the tourist offer based on water - Equipping tourist establishments with water and energy saving equipment	- Few awareness and communication actions - Limited consultation with other stakeholders - Absence of a representative of the use within the Board of Directors of the - ABHL's Board of Directors
Secteur privé (bureaux d'études)	- Partnership with ONEE and ABHL, … - Competences and efficient techniques - Studies and works programmed in the master plans	- These contractors are excluded from all water policy consultation processes
Chercheurs et Scientifiques	- Mastery of techniques and expertise	- Low involvement in the water decision-making process

The multidisciplinary nature of water implies "the existence of fragmented competencies, shared responsibilities, overlaps and even duplication" [9]. The multiplicity of administrative bodies with competencies in the water sector should not be an obstacle, since their actions should converge towards the achievement of water policy objectives.

However, the poor coordination and lack of exchange between the various bodies makes the task difficult. Indeed, the rules of coordination are not defined, which accentuates the fragmentation of responsibilities between the different sectoral institutions in the development of water resources.

Thanks to the new communal charter, the communes have become key players in water management (public drinking water supply and wastewater collection networks, control of non-collective sanitation systems, regulation of uses within the catchment protection areas, etc.) in the same way as the water basin agencies. No territorial structure has a monopoly on water policy, and each actor has its share of responsibility and intervention. This results in a multitude of decision-making centers and control bodies and multiple scales of intervention.

However, the multiplicity of stakeholders in the water sector (ministries, public and private institutions, local authorities, etc.), the lack of coordination, the overlapping of roles, the evolution of competencies and responsibilities following the reorganization of ministries and state services and the divergence of motivations weaken water governance, making the system itself fragile.

Some authors speak of a "crisis of institutions" induced by the multiplicity of actors and their relationships [10].

The basin agencies created on the basis of the French model have difficulty in quickly complying with arrangements that are difficult to put in place, and have difficulties with their financing and freedom of action.

The analysis highlights the need to strengthen the role of the ABHL, and to provide it with the means (human, financial and technical) to carry out the missions assigned to them in good conditions (Semi-directive interview with IAV professor, Zagdouni, 2021). Similarly, it is necessary to institute water policing, which remains the weak link in the system.

Also, the communes have been entrusted with the autonomous sanitation of rural agglomerations (Decree N˚2-05-1.533 of 14 moharrem 1427104, 13 February 2006), however, they have neither the technical, human nor financial means to carry out this mission.

Finally, inadequate coordination mechanisms, legal gaps and overlaps, and the inability to match responsibilities with authority and capacity to act are major sources of difficulty when implementing an IWRM approach. Establishing effective coordination mechanisms between different agencies is a critical issue.

Despite the environmental potential that characterizes the Rif region of Morocco, there is a notable lack of information and bibliographic resources on the area. This is not due to the lack of studies carried out in the Nekor Basin, but on the contrary, this area has been the site of several research and studies conducted in partnership with European organizations.

The lack of information and scientific assessments is an additional handicap. Most of the decision makers in the territory have a significant amount of geographic information. However, this information remains scattered and does not allow for the adequate quantification and management of the resource.

The lack of consultation and coordination between the actors responsible for water mobilization, drinking water supply, irrigation, sanitation and water treatment hinders the proper management of water resources.

Water management is not only supply management, but should also include economics and demand management. More rigorous management of demand could thus make it possible to cope with increasing needs.

Furthermore, the problem of financing the water sector (drinking water supply, wastewater recycling, etc.) and adaptation to global warming represents a real constraint to water management. The lack of financial and human resources makes it difficult for both the water basin agencies and the rural municipalities responsible for supplying drinking water to the local population.

The financial system of the water policy is not adapted to the integration of "water and territory" either.

The financial system of water policy is not adapted to the integration of "water and territory", although it is cited as a reference by international NGOs [11]. It does not recognize the positive roles of land use planning on resources and does not encourage good practices.

While the social and territorial mutations induced by the industrialization of the basin and the advance of urbanization require more sophisticated, efficient and eco-efficient infrastructures and an effective organization. Such a system is generally expensive and poses a challenge to ensure access to fresh water for the poorest.

The unit of Al Hoceima has delegated the management of water and sanitation, opting for the public partnership mode. By ensuring the prerogatives of public power (control, organization and ownership of infrastructure). The operation is delegated to ONEE for 100% of the water supply networks.

Drinking water tariffs are set by the State according to technical considerations and political issues. Indeed, the State ensures a balance between the internal profitability of the water supply organizations and the access of the greatest number of people to water resources, while reconciling the objectives of three ministries: the Ministry of Public Works, which is subject to the technical constraints of volume and security of supply, the Ministry of the Interior, which is attentive to the social aspects of water distribution to households, and the Ministry in charge of economic affairs, which is sensitive to the coherence of the State's economic and financial policy.

The price of drinking water at the production stage is defined by an interministerial commission. The latter defines the price of water at the distribution point for the centers managed by the distribution boards or by the municipalities and the small centers managed by ONEE. The main features of the tariff system are tariffs set by decree at the production level varying in a ratio of 1 to 2.8; progressive customer prices in three bands for individuals and administrations; and industrial prices reflecting long-term marginal development costs.

The pricing policy adopted by Morocco since 1977 aims to spread costs as evenly as possible while discouraging water wastage. Thus, ONEE applies a fixed fee (9.63 DH) in addition to a social rate for small consumers (less than 6 m^3/quarter), a rate at real cost for the 6 to 12 m^3 bracket, a rate penalizing large consumers (more than 12 m^3/quarter), and a preferential rate for industry (3.21 DH regardless of the quantity consumed)

We can consider the lack of responsibility as one of the main factors that led to this mismanagement of resources. It goes to the very heart of the territorial question, which is that of the mode of management of space, and the different historical sequences that have followed. The colonial sequence is very important, since it brutally eliminated the traditional links between people and their land. This process was not subsequently called into question, it was simply statized.

The aggression against the environment is not the mechanical result of demographic growth. Things are more complex; one must also take into account the behavior of the populations: the mountain dweller who drives his cattle into the forest because he has no other grazing land, and the farmer who practices irrigation, and deepens his well as the water table drops. But, whatever the case studied, there is one constant: the lack of responsibility for the land, which is the very support of life.

The real challenge to overcome in the coming years is the fight against water waste, through the implementation of an agricultural policy designed in terms of resource development and optimization, the control of the lowering of the water table, and the reconsideration of releases by dams when they are full, resulting in large losses of water and flooding of neighboring lands.

The lack of data and the recourse to qualitative and quantitative estimation of the satisfaction of the uses of water resources, the inefficiency of the data collection devices, the low technicality of the installations are as many constraints encountered by the water managers. They often lack elements of analysis, representation, simulation, … allowing the integration of all the phenomena at stake and the different geographical scales concerned. The intertwining of the issues leads to place any action in a systemic context, in order to be able to evaluate its impact at other scales.

Water demand is often assessed in a fragmented and subjective manner due to the sectorization and separation of tasks between the different actors in the water sector. The evaluation of supply is thus based on empirical methods of quantitative evaluation of water resources, not integrating the natural environment in the evaluation, and is based on assumptions of stationarity despite climatic variations and changes in the natural environment.

The lack of knowledge on the relationships between the physical and hydro-morphological parameters and the biological response of the system calls into question the definition of good status and the assessment of the water bodies. Our study thus highlights the areas insufficiently covered by research and the consequences of these "blanks" on the understanding of the overall functioning of the water management system.

In terms of water supply, we are confronted with a problem that can be summarized as the unreliability of data. The data used as a reference are the monographs of water resources carried out by the ABHL, which are more like descriptive reports of certain resources and are far from having scientific quality; or the environmental impact studies containing data extrapolated by the engineering offices, which in general do not take into account the geological diversity, nor the natural environment of the basin, nor the land use The few studies carried out by scientific researchers on the BVN remain fragmentary and only deal with specific problems (erosion, siltation, etc.).

Furthermore, it should be emphasized that the location of the hydrometric stations upstream of the hydrographic network does not allow for a representative network of the basin's hydrology, and to correctly describe the hydrological regime of the Nekor basin.

Efforts must also be made to monitor the natural flows of small streams in order to assess the effects of the anthropization of the BV and the CC on water resources. The same applies to the evaluation of the relationship between land use and water resources, which lacks hydrological and biological data.

4.1. Sensitivity of the Nekor Basin Water Resources to Climate Change

The work of the IPCC (Intergovernmental Panel on Climate Change), assigns the term "climate change" to any change in the climate.

"The work of the IPCC (Intergovernmental Panel on Climate Change) attributes the term "climate change" to any change over time, whether due to natural variability or human activities. In contrast, in the United Nations Framework Convention on Climate Change, the term refers only to changes due to human activities. The Framework Convention uses the term "climate variability" for naturally occurring climate change.

Climate change and the disruption of the water regime make the Nekor watershed a very vulnerable area with water resources that are not only limited, but also unstable: shortage of resources related to rainfall, risk of salinity of the water table near the coastal areas (Rhiss-Nékor water table), decrease in the level of this table without forgetting the degradation of water quality representing a real threat to the socio-economic development of the region.

However, climate change cannot be isolated from other changes affecting the natural environment and more particularly those related to human activities. Also, the water resources of the BVN depend on the variability of rainfall.

Certainly, these changes will have a direct impact on natural systems, and indirectly on socio-economic activities (water stress, decrease in river flows and inputs to dams, drying up of several springs, salinization of shallow aquifers, increase in the cost of water withdrawals from wells and boreholes, worsening of desertification, reduction of cereal cultivation and disappearance of certain crops, disappearance of biodiversity, rise in sea level, etc.). These decreases should reduce the "water" capital to 500 m^3/capita/year by 2050 [12].

The most recent publication of high-resolution climate projections for the northern half of Morocco is that of Filahi [13], which analyzes the results of simulations carried out for the RCP4.5 and RCP8.5 scenarios with 4 different RCMs of 12 km spatial resolution. The results obtained for various temperature indices indicate a clear temperature increase over the whole country, more intense over the eastern part. (**Figure 4**)

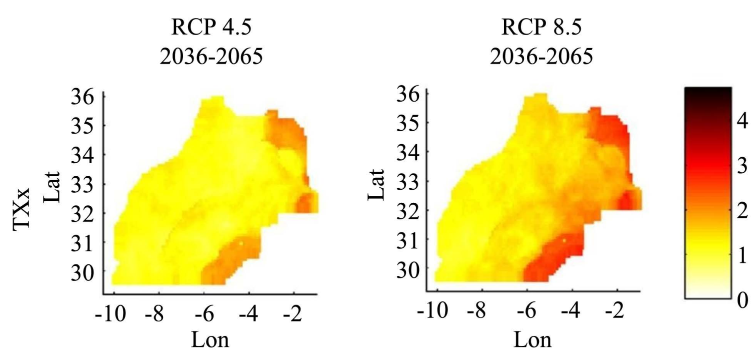

Figure 4. Maximum daily temperature change for the period 2036-2065 compared to 1975-2004 for the RCP4.5 and RCP8.5 scenarios (Filahi *et al.*, 2017).

Regarding the precipitation projection, the set of simulations analyzed in [13] confirm the results of the global models, with a significant decrease in the annual cumulative precipitation over the whole country.

Floods and flash floods, generating significant human and material damage, are indeed usually caused by torrential rainfall events (the case of the study area). (**Figure 5**)

The models simulate a decrease in the annual accumulation associated with extremely wet days (precipitation > 99th percentile), however, projections for other indices characterizing intense rainfall (number of days with precipitation greater than 10 or 20 mm or value of monthly maximum daily precipitation for example) are in disagreement and the signal is unclear for the period 2036-2065 [13].

Changes appear more clearly for the end of the century in the RCP8.5 scenario, with a possible increase in the monthly maximum daily precipitation over the Mediterranean coast, but this projection remains rather uncertain. Previous work by [14] with other MCRs had also shown a possible increase in extreme precipitation on the Mediterranean coast and a decrease on the Atlantic coast, but still with a large uncertainty, especially before 2050. On the other hand, the study by [14] on all the Mediterranean catchment areas by 2100 shows a decrease in extreme precipitation on the southern shore of the Mediterranean. (**Table 4**)

Table 4. Possible impacts of climate change on BVN resources and activity sectors.

Resources and sectors of activity	Likely impacts of climate change
Precipitation (general trends)	Changes in precipitation patterns will have impacts on the hydrological system and erosive processes (heavy precipitation alternating with dry periods will increase soil erosion) as well as vegetation.
Water regimes/water quality	- Increased winter flows (heavy precipitation, flooding) and decreased summer flows by up to 100% due to high evaporation - Draught is much more pronounced in July and August (due to greater evapotranspiration) - Water pollution problems due to the discharge of untreated wastewater by populations
Agriculture, forestry, biodiversity	- Modification of the water regime, a determining factor in the medium term for forest stands (forest cover) and the duration of biological activity - Possible decrease in soil water content - Bour crops will be subject to strong constraints of water availability - Lack of water is a problem for livestock (the concentration of livestock around rare water points favors the circulation of various diseases) - Decrease in crop and forage production (following droughts) - Decrease in forest areas and degradation of forest cover
Tourism	- Conflicts of use for water resources - Decrease in flows and levels favoring eutrophication and various forms of water pollution - Drinking water supply conditions could be affected locally - Decreased water content of soils will have an impact on the landscape

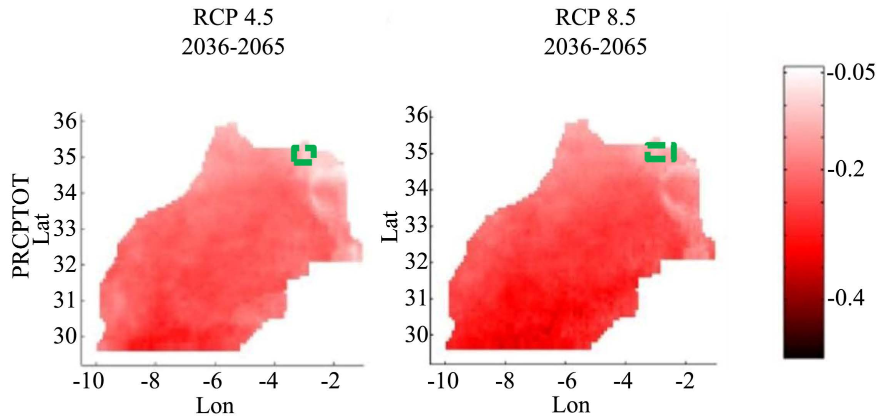

Figure 5. Relative change in annual precipitation for the period 2036-2065 compared to 1975-2004 for the RCP4.5 and RCP8.5 scenarios (Filahi *et al.*, 2017).

The predicted impacts of climate change should make it possible to promote a framework for reflection and cooperation, and actions for the preservation and safeguarding of natural heritage (species and habitats) in the face of climate variations [15].

4.2. Synthesis on Water Management in a Context of Climate Change

In the long term, environmental conditions will change significantly. Much research is focused on climate change and the impacts on water resources, including hydro-sediment budgets and impacts on socio-economic activities. Although the issue of climate change is central, the evolution of the system's environment cannot be reduced to this issue alone. It must take into account the various parameters involved in the functioning and evolution of the environment (variation in uses, changes in practices, etc.).

The system's response depends on the variability of the environment and the direct and indirect impacts on water availability and quality. This complexity makes it difficult to carry out the necessary prospective exercise that must be carried out in the more or less long term on the adaptation and response capacities of the territorial system.

In a systemic approach, "a simulation never gives the optimum or the exact solution to a problem. It only identifies the probable directions of evolution by varying groups of variables and suggesting new hypotheses" (Meeting with Prof. Sabir Mohamed, 2021).

This shows that no single parameter can have an influence on the organization and response of the system. For example, the techniques, even if they are increasingly effective in limiting the impacts of developments on the environment, will be powerless to mitigate the rise in temperature and certain water deficits in periods of severe low water.

As for the three other parameters (knowledge, regulation and institutional system), the expected effects on the system also appear to be limited, especially if the integration of societal actors in the decision-making systems is not developed.

Scientific knowledge is also progressing to meet the requirements of the regulations, and in particular the objective of achieving good status of water bodies. This new knowledge, transmitted to the regulating actors (if the relations between these two categories of actors improve strongly than now), will allow to improve the scope of the institutional system. Moreover, the reorganization of the institutional system that is taking place in the current system will change the competences of the water actors, and in particular the administrative organizations that regulate water policy (ABH). A simplification of the actors is necessary, as governance is based on such a complexity of private and public actors that it weakens the political system itself.

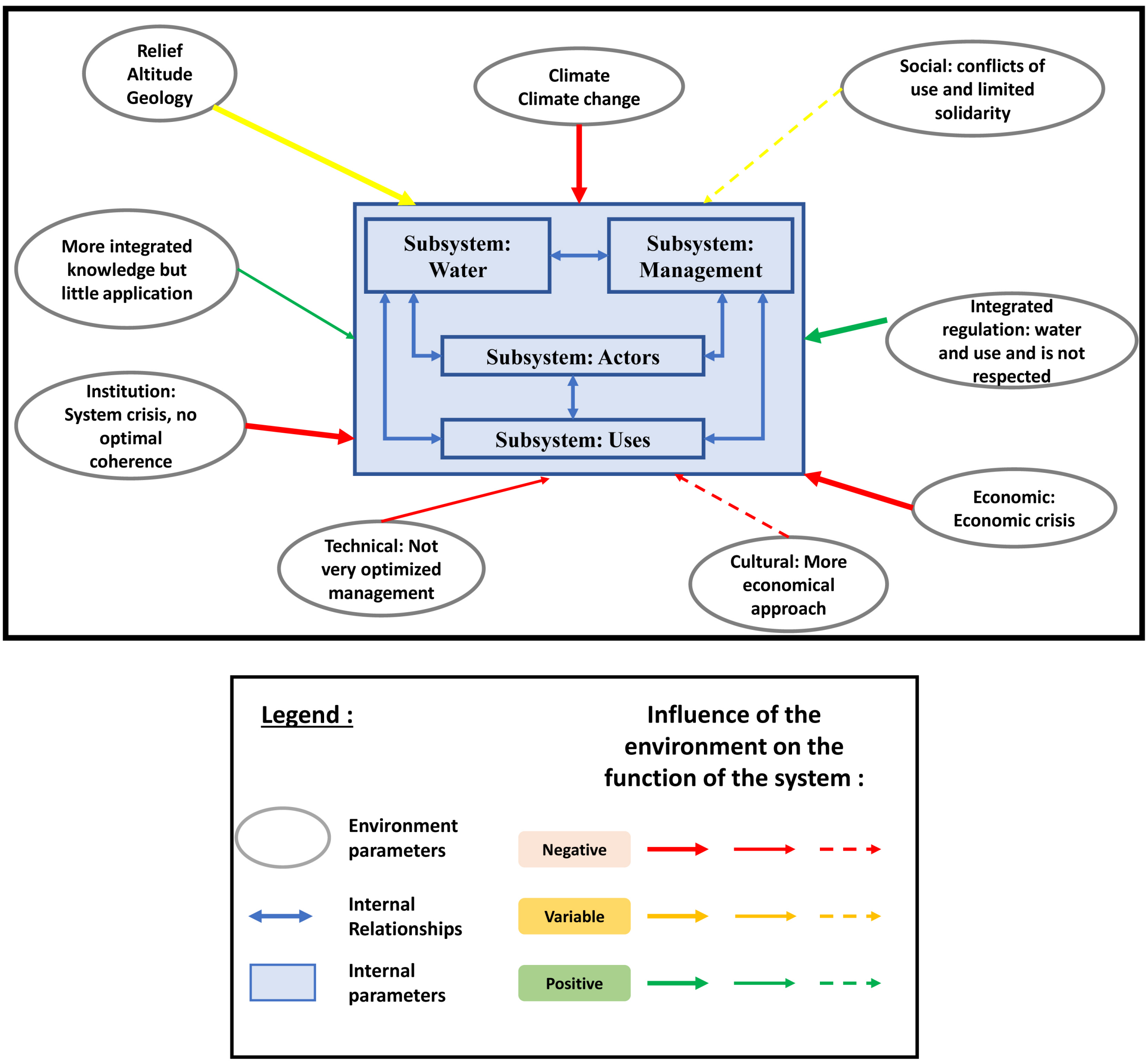

Figure 6. Long-term predictions of environmental influences on the "water management system".

However, for an optimal coherence of the institutional system and an application of regulations and knowledge, the current elements of interaction and integration remain insufficient: poor coordination between ministries, little integration between the different ministries, and a lack of transparency.

However, for an optimal coherence of the institutional system and an application of regulations and knowledge, the current elements of interaction and integration remain insufficient: poor coordination between ministries, little scientific integration at the local level by decision-makers, insufficient dialogue between regulatory actors and local decision-makers, lack of awareness of users on the part of State services… This lack of communication and exchange constitutes a real brake in the evolution of the cultural system which tends to replace the economic approach with a more patrimonial approach to water resources.

As for the social system, the controversies over uses based essentially on a lack of information and dialogue can be mitigated by local consultation tools that would be generalized to the watersheds of Morocco (PDAIRE, groundwater contract). Another obvious development is the grouping of rural communes to manage water resources, driven by the unsustainable price system and by decentralization, which will be accompanied by the eventual disappearance of the department. A form of solidarity between local decision-makers is already emerging through local consultation tools and will tend to be reinforced in the coming decades. The new social system may therefore have a positive influence on the organization of the system. Finally, climate change and the economic system are strongly linked and both will be the strongest forces in the future organization of the management system. (**Figure 6**)

5. Conclusions

The implementation of IWRM in the Nekor Basin must emanate from a regional will and policy based on dialogue and participation of all local forces in resource management. A framework that will promote inter-sectoral collaboration, ensure the effective involvement of citizens, develop partnerships between the various stakeholders in the territory, and eliminate conflicts arising from the fragmentation has occurred in the planning, development and management of water resources.

Improved local water governance cannot be developed without local research on good practices and models that work. Schools and universities have an important role to play in training future water managers. The professional environment will contribute through training to change behavior and professional qualification in the water sector. Decentralization has become a necessity in order to adapt solutions to local problems.

The success of IWRM depends on the ability of stakeholders to perform their functions adequately. This leads us to believe that the capacities of the stakeholders (elected officials, deconcentrated departments, the private sector, society and users) must be strengthened accordingly so that they are able to manage, decide and discuss water issues with technicians in an informed manner and become autonomous.

It is also necessary to reinforce the competences of the municipalities in terms of control and rehabilitation of non-collective sanitation systems and of discharges into the networks and to give them the means to better control rainwater runoff and to know how to recover it for reuse.

The development of synergies and intersectoral approaches and the consideration of cross-cutting aspects, as well as the development of environmental protection and risk management policies (prevention plan, civil security training, information and awareness-raising for inhabitants, reforestation, watercourse maintenance, etc.) can contribute to climate change mitigation or adaptation. It should be recognized that Morocco has undertaken several actions to mitigate the impact of climate change.

Finally, dealing with climate change requires the availability of reliable, territorialized scientific data, and the mobilization of the funds needed to finance research in this area and to meet the challenge of making information and data reliable for use in developing the policy framework. However, knowledge on climate change is too global.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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