



# KINGDOM OF MORROCO COST OF THE DEGRADATION OF WATER RESOURCES IN THE OUM ER-RBIA BASIN

## SUMMARY





## SUMMARY

With a population of 32.2 million in 2011 and a total GDP of U.S. \$ 100.2 billion in 2011, Morocco still faces an endowment of water which rose from 2.560 m<sup>3</sup> / capita / year in 1960 to m<sup>3</sup>/capita/year 730 in 2010, ranking it among the countries with high water stress both regionally (1,100 m<sup>3</sup>/capita/year average ) and globally ( m<sup>3</sup>/capita/year 6,600 on average) . The hydropower potential of the country, which is estimated at 19-17 billion m<sup>3</sup>, consists of 15-13 billion m<sup>3</sup> of surface water and 4 billion m<sup>3</sup> of groundwater. Thus , 87% of its resources are allocated to agriculture and irrigation, and 13% are allocated to drinking water , industry and tourism. In addition, 80% of water resources are located in the watershed of the Centre and North . The agricultural sector contributes about 15% of GDP and 40 % of employment.

Morocco has adopted a new policy in the field of water based on demand management , user participation and pollution at watershed . The demand management , unlike the supply management , will ensure efficiency and operational and economic efficiency of the management of water resources . This approach is to develop an integrated management which includes institutional , legal, economic , social and technical aspects in order to change the behavior of users and achieve a sustainable balance between the limited supply of water and its growing demand.

The cost of the degradation of water resources in the watershed driver Oum Er- Rbia is part of the regional study of the cost of degradation of water resources at the watershed scale and is supported by the SWIM- SM project funded by a grant from the European Union to the tune of 7.0 million Euros. SWIM- SM is a program of local support which aims to actively encourage wider dissemination of sustainable policies and practices of water management in the region, in the context of increasing water scarcity associated with pressure on water resources by a large part of users and desertification , climate change.

Morocco through its National Focal Point has requested the assistance of SWIM- SM to estimate the cost of degradation of water resources in the watershed of the Oum Er- Rbia (see Section 4). The choice of this basin based on the following reasons: (i ) Oum Er- Rbia is the second Moroccan river in length with a linear 550 km. It rises at an altitude of 1,240 m in the Middle Atlas 40 km from the city of Kenifra and empties into the Atlantic Ocean at the city of Azemmour (ii) the basin of the Oum Er- Rbia an area of 35,000 km<sup>2</sup> ( nearly 7% of the total land area ) is subject to different climates ranging , from downstream to upstream , a moderate climate on the Atlantic through an arid climate and semi -arid (iii) the hydrological basin of Oum Er- Rbia is considered among the strategic basins of Morocco . It is " the cornerstone " of the hydroelectric system producing 70 % of the national hydropower, with an average of 762 GW / h. In addition , irrigation representing more than 20 % of the agricultural area area is considered the largest irrigated area in all of Morocco (iv) the basin of the Oum Er- Rbia has 16 dams with a capacity total storage of 5,100 million m<sup>3</sup>. It supplies drinking and industrial water for the entire region of the basin as well as for cities outside the basin including Casablanca, Settat, Marrakech Berrechid and (v) the activities of the basin are diverse and include



agriculture , industry mining and especially phosphates, food industries and transformation. It is one of the most polluted basins in Morocco arriving in second place after the Sebou basin . The water quality is degraded due to domestic, agricultural and industrial waste , and ( vi) the basin of the Oum Er- Rbia was the subject of many reports and scientific and technical information. However, none of these studies addressed the economic dimension of the degradation of the basin and the costs of rehabilitation to overcome this degradation.

The main objective is to evaluate the cost of degradation of water resources at the watershed of the Oum Er- Rbia to help decision makers at national and local level to identify and prioritize specific actions to improve management of the basin through the funding potential projects related to environmental benefits and reduction of externalities.

The costs of degradation Oum Er- Rbia were calculated on two base years 2007 and 2010 are shown in Table 1 and Figure 1 . It should be noted that 2007 is characterized as a dry year, while 2010 was characterized as a wet year . However, urban and agricultural served by transfers Basin Oum Er- Rbia (1,600 million m<sup>3</sup>/year ) as Casablanca, Safi, El Jadida, El Haouz Doukkala and were not included in the evaluation cost of degradation of the fact that the volume is a constant annual transfer and the effectiveness and efficiency of water use should be analyzed separately.

Thus , the total cost of the degradation of 2007 and 2010 are compared both to the Moroccan GDP current ( 616 and 764 million DM in 2007 and 2010) that GDP Basin Oum Er- Rbia ( 67 and 80 billion DM in 2007 and 2010). The latter was extrapolated using the GDP per capita for the basin of the Oum Er- Rbia ( 13,118 and DM 15,773 / capita respectively in 2007 and 2010 based on disposable income ) and multiplying by the number of inhabitants is 4.9 and 5.1 million respectively in 2007 and 2010.

In 2007, the cost of degradation of the Oum Er- Rbia amounted to 6.2 billion DM with a variation from 4.6 to 7.2 billion DM . These costs represent 9.3% of GDP in the Oum Er- Rbia 1% of Morocco's GDP in current term but 1.1 % of Morocco's GDP in constant term (2000). The cost attributable to human health is DM 2.19 billion or 35.2 % of the cost of degradation of the Oum Er- Rbia.

In 2010, the cost of degradation of the Oum Er- Rbia amounted to 6.3 billion DM with a variation from 4.7 to 7.4 billion DM . These costs represent 7.9% of GDP in the Oum Er- Rbia , 0.8% of Morocco's GDP in current term but 1.0% of Morocco's GDP in constant term ( in relation to 2000). The cost attributable to human health is DM 2.27 billion or 35.8 % of the cost of degradation of the Oum Er- Rbia .

*Table 1 : Cost of Degradation of Oum Er-Rbia, 2007 and 2010*

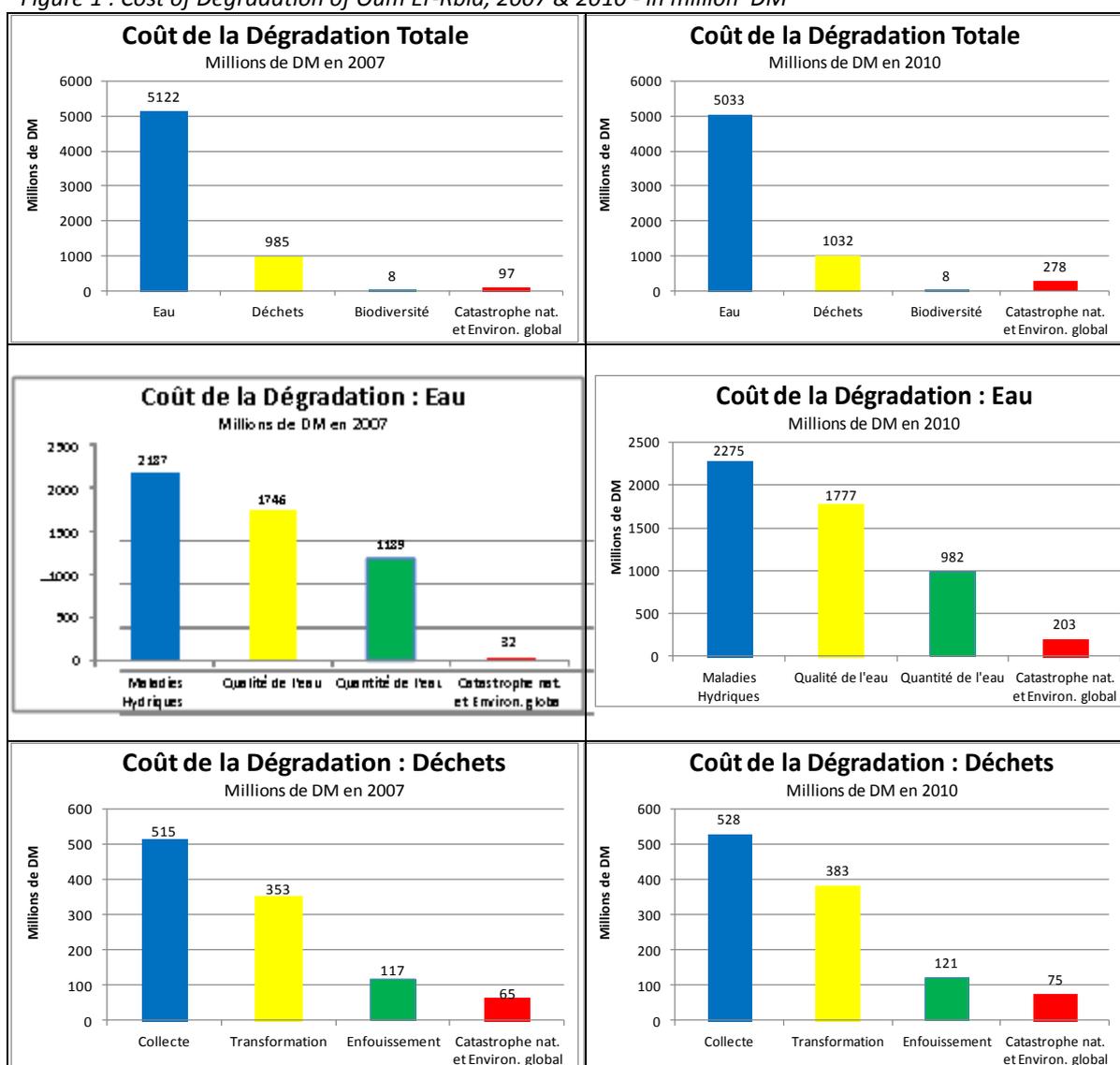
CATEGORIES	Coût de la dégradation de l'Oum Er-Rbia			
	Average Term. Million DM	%	Lower Term. Million DM	Superior Term. million DM
<b>Dry year 2007</b>				
<b>Waste</b>	5.121,7	82,5%	3.732,2	6.000,1
<b>Waste</b>	985,4	15,9%	841,4	1098,1



<b>Biodiversity</b>	7,6	0,1%	6,8	>7,6
<b>Natural Disaster and Global Environment</b>	97,2	1,6%	28,7	100,5
<b>Total</b>	<b>6.211,7</b>	<b>100%</b>	<b>4.609,2</b>	<b>7.198,6</b>
<b>% current GDP / Oum Er-Rbia (67 bio. DM)</b>	<b>9,3%</b>		<b>6,9%</b>	<b>10,8%</b>
<b>% current GDP / Morrocco (616 bio. DM)</b>	<b>1,0%</b>		<b>0,7%</b>	<b>1,2%</b>
<b>Wet year 2010</b>				
<b>Water</b>	5.033,1	79,3%	3.571,8	5.940,5
<b>Waste</b>	1.031,5	16,2%	885,4	1.153,6
<b>Biodiversity</b>	8,3	0,1%	7,4	>8,3
<b>Natural Disasters and Global Disasters</b>	278,0	4,4%	202,9	278,5
<b>Total</b>	<b>6.350,9</b>	<b>100%</b>	<b>4.667,6</b>	<b>7.372,6</b>
<b>% current GDP/ Oum Er-Rbia (80 bio. DM)</b>	<b>7,9%</b>		<b>5,8%</b>	<b>9,2%</b>
<b>% current GDP / Morrocco (764 bio. DM)</b>	<b>0,8%</b>		<b>0,6%</b>	<b>1,0%</b>

Source: the Authors

Figure 1 : Cost of Degradation of Oum Er-Rbia, 2007 & 2010 - in million DM



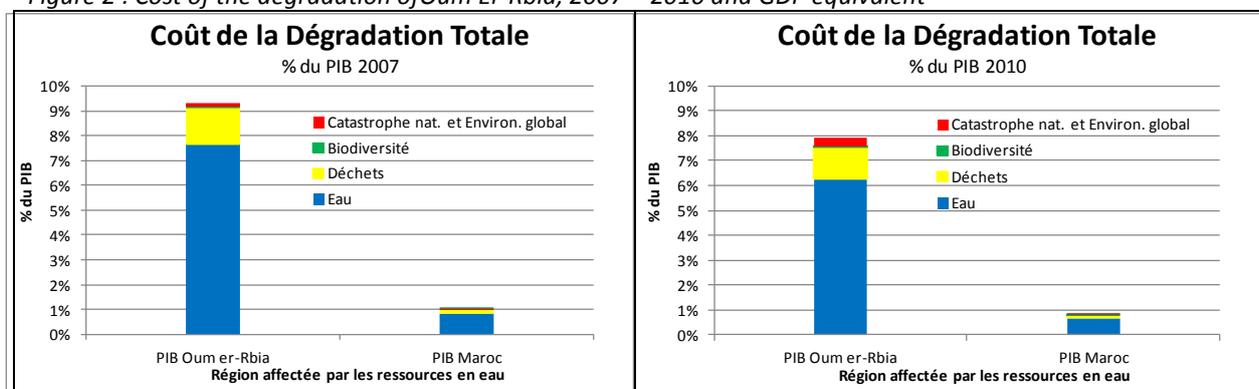
Source : The Authors



Broken down by category in 2007 (Table 2 and Figure 2) , the degradation of water is the most important in the Oum Er- Rbia in absolute values ( DM 5.1 billion in 2007) and 83% relative compared in total. Waste come second ( 1.1 billion DM in 2007) with 16.9% and relatively biodiversity 0.1% - natural disasters and greenhouse gases are included in the above categories . Broken down by subcategory water, waterborne diseases account for the majority of the costs of Oum Er- Rbia followed by the quality of water (1.7 billion DM) , the amount of water ( 1.2 billion DM ) and finally the global environment by including natural disasters and greenhouse gas emissions (3 million DM) . Broken down by subcategory waste collection represents the majority of the costs of Oum Er- Rbia (515 million DM) followed by processing waste ( 353 million DM) , landfill ( 117 million DM) and finally the global environment (65 million DM) .

Broken down by category in 2010 ( Table 2 and Figure 2), the degradation of water is the most important in the Oum Er- Rbia and in absolute values ( DM 5.2 billion in 2010) and on 82.5 % based on the total . Waste come second ( 1.1 billion DM in 2010) with 17.4% and relatively biodiversity 0.1% - natural disasters and greenhouse gases are included in the above categories . Broken down by subcategory water ( 5.2 billion DM in 2010) , water-borne diseases account for the majority of the costs of Oum Er- Rbia followed by the quality of water (1.8 billion DM ) the amount of water (1 billion DM ) and finally the global environment by including natural disasters and greenhouse gas emissions ( 203 million DM) . Broken down by subcategory waste collection represents the majority of the costs of Oum Er- Rbia ( 528 million DM) followed by processing waste ( 383 million DM) , landfill ( 121 million DM) and finally the global environment (75 million DM).

Figure 2 : Cost of the degradation of Oum Er-Rbia, 2007 - 2010 and GDP equivalent



Source : The Authors

Table 2 : Cost of the degradation of Oum Er-Rbia itemized by sub-category, 2007 et 2010

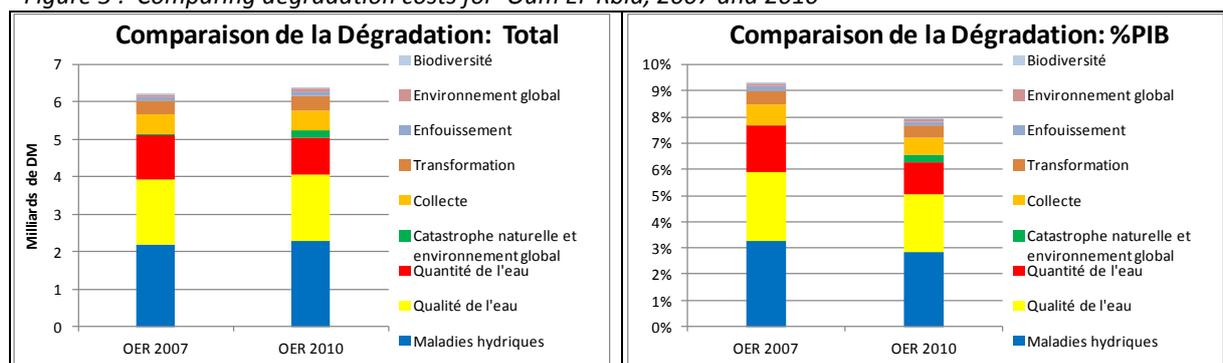
	Cost of degradation of Oum Er-Rbia Mil ioDM			
	2007	%	2010	%
<b>Water</b>	5.154	83,0%	5.237	82,5%
<b>Waterborne Diseases</b>	2.187	35,2%	2.275	35,8%
<b>Water quality</b>	1.746	28,1%	1.777	28,0%
<b>Water quantity</b>	1.189	19,1%	982	15,5%
<b>Natural disasters and global environment</b>	32	0,5%	203	3,2%
<b>Waste</b>	1.050	16,9%	1.106	17,4%
<b>Waste removal</b>	515	8,3%	528	8,3%



Transformation	353	5,7%	383	6,0%
Burial	117	1,9%	121	1,9%
Global environment	65	1,0%	75	1,2%
Biodiversity	8	0,1%	8	0,1%
<b>Total</b>	<b>6.212</b>	<b>100,0%</b>	<b>6.351</b>	<b>100,0%</b>

Note: Costs associated with natural disasters and the global environment were aggregated in each category.  
Source: The Authors.

Figure 3 : Comparing degradation costs for 'Oum Er-Rbia, 2007 and 2010



Source : the Authors

Moreover, the comparison of degradation costs in 2007 ( dry year ) and 2010 ( wet year ) leaves appear a significant difference in terms of GDP ranging from 1% in 2007 to 0.8% in 2010 compared to Morocco's GDP ( Table 2 and Figure 3 ) . But this difference is even more significant when the OER GDP is considered : the difference is 1.4%. However, this difference is not entirely due to different wet and dry years, but in part to the increase in GDP over the period ( 4.2% per year on average) compared to the increase in pollution. The three sub-categories that make the difference of wet and dry years are: the additional drawdown due to pumping of groundwater (65 million DM) and reduced hydroelectric production ( 255 million DM including the additional cost of GHG ) to be offset by production from fossil fuels in 2007 and costs associated with victims , damages and lost profits ( estimated at DM 200 million ) in 2010. Thus, the cost of additional deterioration in 2007 amounted to 319 million DM in 2007 which for 2010 is estimated flood DM 200 million cost. However , this comparison between years is only preliminary and deserves a more detailed analysis in order to identify differences such as increasing the productivity of rain-fed and irrigated agriculture which have a great impact on revenues and increasing vulnerability farmers

Based on priorities identified in the previous section, four scenarios of interventions were considered but only three were completed. Only categories effectiveness of irrigation, drinking water, and sanitation in rural areas and landfill management were evaluated. Interventions related to land and to reduce erosion and siltation of dams were not considered due to lack of studies to establish a causal link between the organization and reduction of siltation to conduct a financial evaluation .

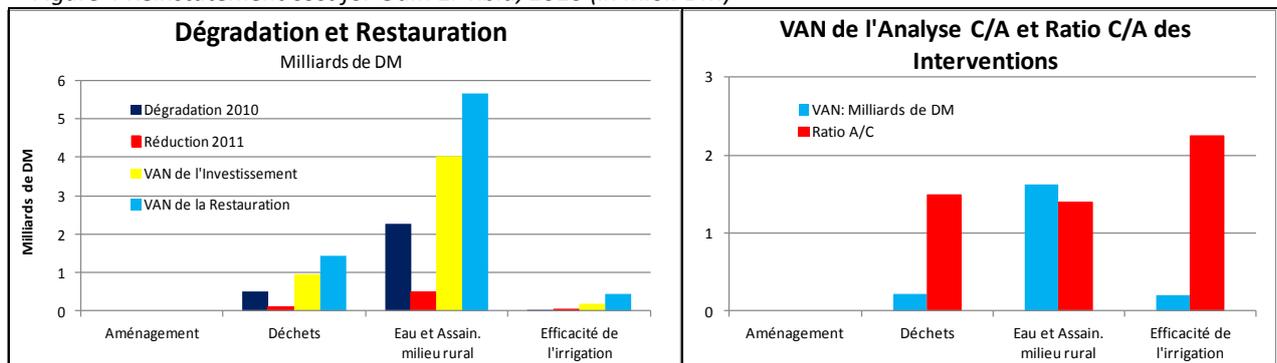


Table 3 : Reinstatement cost for Oum Er-Rbia, 2010 in bio. DM

Intervention	Degradation	Reduction	NAV	NAV	NAV Analysis C/A
	2010	2011	investment	Reinstatement	
	billion DM	billion DM	billion DM	billion DM	Billion DM
Planning	0	0	0	0	5.497-29.532 DM/ha 6.433-31.579 DM/ha
Waste	0,5	0,1	1,0	1,4	0,2
Water / Rural Sanitation	2,3	0,5	4,0	5,7	1,6
Irrigation efficacy	0,04	0,04	0,19	0,43	0,20

Source : Auteurs.

Figure 4 Reinstatement cost for Oum Er-Rbia, 2010 (in mioi. DM)



Source: Auteurs.

The most efficient scenarios were selected and are shown in Table 3 and Figure 4. The profitability of the effectiveness of large-scale irrigation and no doubt could have a positive return on investment after only 5 years. On water and sanitation in rural areas, all scenarios are profitable. For waste alone any alternative to landfill with electricity generation in cells is profitable. Alternatives with segregation and recycling are not because they are too expensive. Thus, to overcome this shortcoming, a multi-criteria analysis could be considered for decision making where the weights are assigned not only to analyze C / A but also to the creation of employment, poverty reduction , etc. .

Cost analysis of restoration of three categories analyzed and based on the net present value (NPV ) of the investment over 20 years ( 21 years for waste) with a escopmpte rate of 10% and the internal rate of return (TRI) , has identified the most effective and efficient investments are:

- For irrigation , the investment will save 200 million m3 that can be used to reduce the structural deficit in the pool or possibly marginally increase the irrigated areas. The analysis shows a positive NPV of DM 189 million , an IRR of over 10% and VA Ratio A / C greater than 1.
- The assainissement is profitable with or without water and produce an NPV of 1,617,000 DM , an IRR of over 10% and VA Ratio A / C greater than 1.
- Transfer and disposal of municipal waste is only profitable when for each governorate , a transfer station and landfill will be established with electricity through methane



emissions . This investment will have a positive NPV of 226 million DM , an IRR of 17% and a VA Ratio A / C 1.5 .

Diagnosis and analysis that have been developed in the previous chapters are used to arrive at six general conclusions :

- Lack of access to safe drinking water and sanitation in peri-urban and rural areas is the cost of the most important degradation was estimated at 2.2 billion DM . In its NAP , the Moroccan Government has prioritized investment in urban areas of the basin , however, the estimation of degradation showed that access to drinking water and sanitation is considered the number one priority needs rural and peri-urban population of the basin , as it mainly affects the health of this population. Moroccan statistics showed 1,139 deaths due to diarrhea on 19.36 newborns per 1,000 inhabitants in 2010. The prevalence of diarrhea was 2.5 cases per child under 5 years and 0.5 cases per population equal to or more than 5 years.
- Untreated waste is the second source of degradation of water resources in the basin of the Oum Er- Rbia and estimated at 888 million DM . The PNDM granted significant investment in the collection and landfill in urban areas , however, are wild dumps and the weakness of the collection and disposal of waste in peri-urban rural areas are also significant.
- The loss of irrigated agricultural productivity due to salinity is ranked third perspective and damage estimated at 775 million DM . Despite the use of fertilizers, a third loss of productivity in the basin of the Oum Er- Rbia is due to degradation due to soil salinity is particularly related to the quality of irrigation water .
- Damage related to erosion are also important and are estimated at 285 million DM . The complex relationship between episodes of erosive rainfall and annual rates of soil loss can be explained by two important factors. The first factor is related to the cycle of soil degradation determines the potential of soil erosion in the basin. The second factor corresponds to the orientation of the degradation .
- Measures , data and reports on the quality and quantity of water resources as well as qualitative assessments of impacts on natural resources are generally understood from a technical point of view, however , economic evaluations of these impacts are almost non-existent .
- The fact that the water and the environment belong to the same department has strengthened the synergies between these two departments. However the area of the water and the environmental sector are characterized by a juxtaposition of two departments with lines inaccurate decisions on the problem of water quality . The Department of Environment is rather focused on the control of industrial pollution , however, the decision on the quality of the water that falls from the Department of Water and ABHRH and skills department environment are considered only as an opinion or advice , and this lack of integration and transversal considerations. .

Six areas are proposed for the integrated and sustainable management of water resources of the Oum Er- Rbia underlying the recommendations of this study :



- a) **Focusing primarily on efficient investment for controlling indoor air pollution in rural and peri-rural areas that have been neglected in the past.** Here are the priorities to be considered :
- i. It is important that the Government would invest first in the extension of drinking water and sanitation in rural areas of the basin where poverty is predominant, using appropriate technologies. There is an institutional vacuum in the responsibility for the planning and implementation of water and sanitation in rural areas of the basin of Oum Er- Rbia . This should be addressed by the Ministry of Interior in the development of the sanitation strategy that will be associated with access to drinking water, but based on persuasive economic and environmental factors , and provided with monitoring indicators such as the reduction of the cost of degradation of water resources.
  - ii. A similar strategy PNDM for waste management in peri-urban and rural area as well as the closure of uncontrolled dumps is strongly advised . However, the institutional aspects ( role of the municipality and the operator control facilities available ) and the limited financial capacity of municipalities in the Oum Er- Rbia , particularly small and medium-sized them a major constraint for waste management in rural and peri-urban area and should be analyzed in the proposed strategy.
- b) **Consideration of opportunities to increase agricultural productivity by reducing the impact of salinity.** The following opportunities can be considered as improving the efficiency of irrigation systems, the use of micro-irrigation such as drip and consideration of other agricultural products that are tolerant to salinity (wheat, sugar beet and citrus) instead of vegetable crops and the land where salinity levels are very high.
- c) **The gradual policy shift intensification of exploitation of natural resources, particularly in the context of resource mobilization in surface water and groundwater that are exploited in the basin of the Oum Er-Rbia.** This shift can be made on the basis of criteria that explicitly include economic performance and degradation and scarcity of resources in the basin. This will allow one hand, a better use of water resources and secondly integrate conservation concerns of "soil and water" heritage, and improving productivity.
- d) **Planning upstream interventions may reduce siltation of dams** need to derive the determinants of siltation and assess the exact impact of erosion control regarding the control and mobilization of surface water and adaptation of erosion control techniques for their effective use by operators
- e) **A decentralized information network for observation , monitoring , monitoring of environments and basin of Oum Er- Rbia natural resources.** This network should be reoriented in partnership with institutions of water, ABHOER and the environment. This network will aim to
- i . define and validate continuous exchange protocols and cooperation with other information sources and databases;
  - ii . undertake measures the state of soil and water in order to reflect the understanding and assessment of the environment and its impact on health and



the degradation of natural capital and to contribute to decision making based on data and accurate and regular information and ;  
iii . provide all users , all information and data on the nature and quality of water and soil as well as the constraints and incentives.

- f) **A horizontal action dimension for a comprehensive and integrated thinking on water management in the watershed of the Oum Er- Rbia is highly recommended.** Effective and efficient investments are not sufficient to ensure the multi- sectorial nature and cooperation between ministries, the ABHOER , local institutions and beneficiaries. Provincial Water Commission Oum Er- Rbia may constitute a transverse study group composed of representatives of ministries ( Water and Environment , Interior, Agriculture and Health), their guardianship institutions such as ONEP and the ABHOER and user representatives will be mandated in the first place :

- i . develop expertise in the assessment of benefits and damages and water conservation , and advice in the ways and means of integrating these aspects into programs and sectorial development strategies and*
- ii . establish a system of monitoring and evaluation for investments and activities in the basin.*