Groundwater Management in Morocco

Draft Synthesis Report

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1 Background

• Figure 1 Morocco

Morocco has a land area of 446,000 km^2 of which 9.3 Mha are cultivated. The climate is influenced by the Atlantic Ocean and the Mediterranean but is predominantly semi-arid. It has cold wet winters and hot dry summers with an average rainfall of 346 mm/yr varying from 750mm in the northwest along the coast to less than 150mm in the southeast where irrigation is essential for agriculture. The country can be divided into four water resources zones:

- Coastal plains, which extend along the entire coast. Most of the country's rivers flow through these plains.
- The hills to the north, parallel to the Mediterranean Sea, known as the Rif mountains.
- The hills in the center extending from northeast to southwest. They include the mountain ranges of the Middle Atlas, High Atlas, and the Anti-Atlas, which are almost parallel to each other.
- The desert hills, which are extensions of the southern slopes of the High Atlas and Anti Atlas.

The population in 2004 was just over 31 million – 42 percent in the rural areas. In the 1960s this was over 70 percent. The population is growing at 1.7 percent and so by 2030 it is expected to reach over 40 million.

Morocco has a strong agricultural economy but this fluctuates in line with the weather and so imports of basic foods such as cereals, sugar, vegetable oils and to a lesser extent dairy products are essential.

2 Water resources and water use

Surface and groundwater resources and an assessment of water withdrawals are summarized from the FAO AQUASTAT database in Table 1. Renewable water resources are estimated at 29,000 MCM/yr. Groundwater is about one third of this but only about 4,000 MCM/yr is exploitable. Groundwater is well distributed across the country, unlike surface water which is mostly concentrated in the Loukkos, Sebou, and Umm Rbia basins and regulated through 104 large dams (capacity 16 MCM) and many smaller dams. Wastewater re-use contributed 500 MCM/yr in 2000 but this is likely to rise to 1,500 MCM by 2020. The use of desalinated water is also growing from 7 MCM/yr in 2000 to an expected forecast of 51.4 MCM/yr by 2020.

• Table 1 Annual water resources and water use in Morocco (from FAO AQUASTAT 2000)

Resource	Renewable	Exploitable
Surface water (MCM)	22,000	16,000
Groundwater (MCM)	10,000	4,000
Overlap (between sw and gw)	-3,000	
Total (MCM)	29,000	20,000
Dam capacity	16,100	
Total/capita (CM)	935	
Withdrawals		
By sector		
Agriculture (MCM)	11,000	
Domestic (MCM)	1,230	
Industrial (MCM)	360	
Total withdrawals (MCM)	12,590	
Water withdrawal/capita (CM)	406	
By source		
Surface water	9,430	
Groundwater	3,170	

3 Matching groundwater supply and demand

Morocco is geologically and hydrologically diverse with 50 hydro-geological catchments. Studies have identified some 126 aquifers – about half are shallow aquifers (less than 200m) and half are classified as deep. The degree of knowledge of these aquifers varies. More is known about the shallow aquifers although some deep aquifers close to the Sahara region have also been studied in detail.

Although FAO AQUASTAT data suggests that there is 4,000 MCM/yr of renewable and exploitable groundwater, the Country Report suggests that this is much lower at present – 2,570 MCM/yr – while overall groundwater use is 3,507 MCM (Table 2). These data demonstrate that all ten main catchments are being over-exploited and nationally the excess of demand over supply is about 932 MCM/yr. Deep, non-renewable groundwater contributes a further 500 MCM. Falling groundwater levels are further evidence of over-exploitation as is the drying up of Khettaras (underground tunnels that enable groundwater to flow under gravity into oases). These are not precise figures because many of the data are estimates rather than the result of detailed study. However, they do provide a strong indication of availability and over-exploitation. This situation is most likely to worsen as the demand for water increases and the fact that in many cases, groundwater is much more easily accessed than surface water.

• Table 2 Groundwater available and exploited by catchment (MCM/yr)

Catchment	Number of aquifers	Renewable resources	Exploitable resources	Exploited resources	Over-exploitation
Loukkos	40	406.3	58.6	63.6	5.0
Moulouya	15	267.5	200.3	255.3	55.1
Sebou	6	1,561.8	678.4	769.4	91.0
BR Chawia	3	97.0	71.4	144.6	73.2
Oum Er Rabia	8	619.3	467.8	582.8	115.1
Tensift	14	167.5	340.5	552.6	212.1
Souss	4	336.8	345.0	641.4	296.4
Draa	34	283.2	236.5	258.8	22.3
Ziz		312.6	174.3	220.0	45.7
Saquiat El Hamra	2	2.5	2.5	18.9	16.4
Total	**126**	**4,054.5**	**2,575.1**	**3,507.4**	**932.3**

Source: Country Report

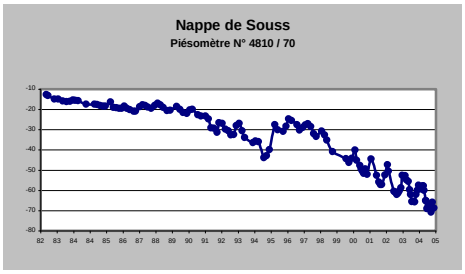
Souss is one of the most over-exploited catchments. In 1940 the whole of agriculture consumed only 8 MCM/yr but as the exploitation of the Souss plain began, groundwater consumption increased and by 1956 it reached 22 MCM/yr. By 1969 it was 124 MCM/yr. During the 1960s and 70s modern irrigation development expanded alongside the more traditional water abstraction methods but in an uncontrolled manner, particularly in the private sector. By 2004 withdrawals for agriculture had reached over 500 MCM/yr and water balance studies verified the growing concerns about over-abstraction (Table 3). Successions of dry summers since the 1970s and the drying up of some 60 natural springs added more evidence as did the drying up of the Wadi Souss whose base flow was an important water source up to 1970.

Other catchments follow a similar trend with water tables falling in some cases more than 2m/yr. This also impacts on stream flows, dam storage, and springs which are fed from groundwater.

• Table 3 Water balance for Souss aquifer (MCM)

Water basin	1976	1979	1985	1994	1996	1998	2003
Inflow	220	337	163	108	870	256	323
Outflow							
- Underground flow to sea	22.0	19.9	15.0	19.0	142.0	16.4	3.8
- Traditional irrigation (springs, Khettaras)	116.0	73.7	11.1	65.4	33.8	67.6	518.9
- Modern public and private irrigation	250.6	278.1	365.4	375.0	431.0	488.0	
- Potable water and industry	8.1	9.8	16.8	18.6	30.0	41.9	28.7
Total outflows	405	442	408	478	637	614	551
Balance	-185	-105	-245	-370	233	-358	-228

Source: Country Report



• Figure 2 Falling piezometric levels at Souss

The reasons for over-exploitation are seen as the result of poor overall management by government institutions, a political emphasis towards surface water resources, public subsidies for irrigation that encourage

groundwater exploitation, and a general disrespect by users for groundwater legislation and regulations. More recent groundwater preservation projects have demonstrated ways of promoting more sustainable groundwater management. They show that it is crucial to mobilize all the stakeholders in the conception, implementation, and management of groundwater. Success is linked to empowering stakeholders, particularly end users, to take responsibility for groundwater management.

3.1 Recharge

Most of Morocco's aquifers are naturally recharged at varying rates and few are what might be called fossil aquifers and non-rechargeable. Some do exist in the south of the country in the basin of Saquiat El Hamra and Oued Eddahab close to the Sahara. As recharge is very slow – up to 5 MCM/yr – and the reserves are limited to about 3,000 MCM the available water is used mainly for potable water supply and for small irrigated areas in some localities.

In most other aquifers, natural recharge maintains the existing flows but there are now plans to augment these resources using artificial recharge schemes. Already the Charf El Akab aquifer is used as an upstream regulation reservoir for water supply to Tangier an Assilah; and storage from Wadi Souss in Aoulouz dam, constructed in 1991, recharges the Souss aquifer beneath the reservoir. 'Seepage' from other dams indirectly recharges other aquifers such as the Beni Smir dam in Khouribga province and the dam on the wadi Saquita El Hamra near the city of Laayoune in the Moroccan Sahara.

Underground dams are also used to control underground streams in Maaider basin to the East of Atlas.

4 Drivers for change

Groundwater has always played a key role in Morocco's socio-economic development supplying water for domestic use, for industry, and for irrigated agriculture. For centuries the traditional water abstraction methods, such as shallow wells, springs, and Khettaras, maintained a balance between supply and demand. But modern irrigation and deep well pumping shifted this balance as the demand for water increased exponentially. The sustainability of water supplies is now threatened as is the socio-cultural heritage of water resources management. The old order of local and tribal rules and management is being fragmented by the introduction on modern exploitation and management practices. The legal system and the modern adaptation to Islamic law is supplanting the traditional approach to resolving conflicts. Exploitation is led by finance, credit, and the technology to drill deep wells.

4.1 Agriculture

Irrigation is by far the largest user and consumes over 90 percent of the available water resources – both surface and groundwater. It is irrigation that has enabled agriculture to intensify production per hectare of land (Table 1). Although only 16 percent of the cultivated land is irrigated, it accounts for over 45 percent of the value of agricultural production and 75 percent of Morocco's exports. In a dry year like 1994-95 irrigation's contribution to agricultural added value can be as high as 70 percent. In 2004 it was estimated that of the potentially irrigable land area of 1.66 Mha about 1.46 Mha was equipped for irrigation – just over 750,000 ha was government run and the remaining 620,000 ha was privately operated (approximately 180,000 ha of privately irrigated land lies within the government controlled irrigation areas).

Groundwater plays an important role in agriculture. Only 37 percent of the area equipped for irrigation uses groundwater but it is the main water source for most private farmers who grow high value crops, notably orchard crops and vegetables, and who contribute about half the

economic value added by irrigation (Table 4). Groundwater is also the main source of water for people living in rural communities. They see groundwater as a reliable and sustainable water supply, particularly in dry years. The costs of accessing groundwater too are usually less than for developing surface water supplies.

Data are available to show the extent of irrigation from each of the main aquifers. The Sebou, Tensift, Sous, and Oum Er Rabia together supply groundwater to nearly 60 percent of the privately irrigated land.

• Table 4 Sources of water for private irrigation areas

Private irrigation (ha)	Area per water source (ha)					
	Groundwater	Wadis	Dams	Waste water	Mixed	Not known
626,610	421,140	55,840	3,050	2,730	105,500	38,350

Source: Country Report

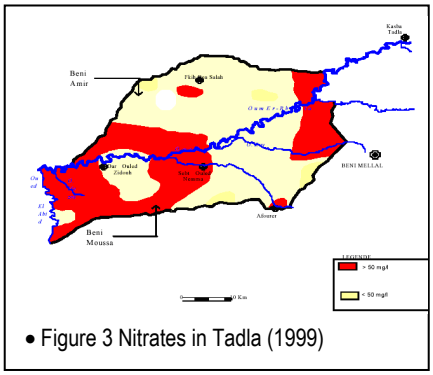
4.2 Water supply and sanitation

Groundwater contributes about 60 percent of the supply to domestic and industrial users. Demand rose four-fold between 1970 and 2005. However, as the population continues to grow the groundwater contribution is now decreasing because of over-exploitation. In rural areas groundwater supplies up to 70 percent of all water needs.

4.3 Environment

Only 10 percent of shallow groundwater is of good quality. Some 32 percent of groundwater was considered to have fair quality, but 58 percent was of poor quality. The aquifers of Berrechid, coastal Chaouia, Kert, Gareb, Bouareg, Beni Amir, and Tafilalt, are saline. The aquifers of Fès-Meknès, Tadla, Abda-Doukkala and Angad are high in nitrates, mainly due to agricultural activities.

The coastal aquifer of Chaouia which extends some 20 kms between Casablanca and Azemmour has been registering saline intrusion since 1980 following the development of vegetable irrigation along the coast. Over-exploitation has led to a continuing decline in the water table of 0.5 m/yr and sea water intrusion extending some 2 km inland.



• Figure 3 Nitrates in Tadla (1999)

Studies in the Tadla catchment during 1966-98 showed nitrate contamination levels varied between 3 and 228 mg/l. On a sample of 100 targeted wells during this period, 14-50 percent of wells had nitrate levels in excess of the national standard for drinking water (50 mg/l). Similar nitrate pollution occurs in the aquifer of M'nasra along the coastal zone of the plain of Gharb. This aquifer is very shallow and is exploited for both agriculture and as a domestic supply to 40,000 people.

Sulphates were found in groundwater in the d'Aîn Béni Mathar basin in the north-west of Souss, in the south-Atlas groove, in Doukkals, and the upper occidental Atlas.

5 Groundwater management

5.1 Institutions governing groundwater

Morocco has the longest experience in the region of devolving responsibility for water management to the lowest administrative level. For groundwater there is a shared responsibility between government, which sets the National Policy for Water through the National Water Plan and regional, and local organisations responsible for exploitation including Water Basin Agencies (ABH), Regional Agricultural Development Office (ORMVA), and Water User Associations.

The Higher Council for Water and Climate, set up in 1981, addresses the issues of water resources and climate. It has a remit to improve the national knowledge strategy on climate and water and to establish the National Water Plan. Half the membership comes from government departments dealing with water and half are representatives from water users, provincial assemblies, higher education, and professional and scientific associations.

Other ministerial departments and organisations are involved to varying degrees in groundwater management, in particular the Ministry of Interior, The Ministry of Agriculture, The Higher Commission of Water and Forest, The Ministry of Water and Mines, The Ministry of Environment, The Ministry of Health, The Ministry of Finance, and the National Potable Water Office (ONEP).

The Ministry of Water is responsible for implementing the National Water Plan at a national level together with seven Water Basin Agencies, covering the majority of the country, which have prime responsibility for planning and administering groundwater at a water basin level. Their role is to support and implement the National Water Plan, control and evaluate water resources, administer and deliver water for the Public Hydraulic Domain (DHP), provide technical and financial support to the various stakeholders, and police water regulations.

Basin Agencies are funded from water charges made to abstractors, such as the DHP, and from central government. Fees from the public water sector have a double objective; they are designed to persuade people to reduce consumption and pollution, and they provide funds for further investment in the preservation of water resources. However, such investments can contradict each other. Subsidies for trickle irrigation equipment for example do not always discourage people from using excessive amounts of water for irrigation; rather they encourage expansion of the irrigated area.

Although significant progress has been made in groundwater governance since 1995, including the establishment of laws governing abstraction and protection in times of drought and protection from pollution, the system is still fragmented and weak. The institutions lack resources to function effectively and so the over-exploitation and pollution of groundwater continues in spite of the actions taken. Authorized withdrawals of water represent only a fraction of the actual withdrawals across the country. The task of regulating groundwater is immense considering the extent of the territory involved, the complexity of the licence granting system, and the lack of materials and resources to police water use.

Groundwater planning is behind what is actually happening on the ground and reports usually now focus on the damage being done to aquifers and the steps required to mitigate their effect. This approach to development is not sustainable and is likely to lead to a water crisis. There is already of crisis in the El Guerdane zone in Souss, where some 3,000 ha of citrus has been lost. More irrigated land is being abandoned in the region of Chtouka-Bir Jdid. This groundwater resource management model is in need of a new vision and good governance.

5.2 The regulatory framework

The new water law is extensive and comprehensive and confirms the principle of public dominance of groundwater, essentially taking into account the dispositions previously introduced by legislation. This leads back to the rules governing water introduced in 1914 which established private water rights alongside those of the public sector. This law takes into account all groundwater sources.

The law puts the control of groundwater quantity, quality, pollution, and allocation, in particular in times of scarcity, in the hands of the Water Basin Agencies even though many other ministerial departments, public structures and institutions are also involved in similar activities. However, the absence of metering means that the Agencies cannot monitor actual water withdrawals.

The law also provides for the participation of water users in groundwater management but as yet the full participation of users and their empowerment to do so remains poor.

5.3 Economic instruments

Water charges are made for domestic and industrial groundwater use as well as for agriculture. The principle of the user-payer is enshrined in the law and the rate is fixed at US$0.024/CM for irrigation water supplied to government run schemes. Users pay 75 percent of the cost recovery and operating costs which amounts to US$0.075/CM. However, these charges are made only on government run schemes. Privately owned schemes are not charged as they must bear their own capital investment and operating costs.

It was anticipated that the water charges would encourage water savings. But in practice they represent only a small portion of the cost of pumping water and so they have little impact on farm water consumption. Also the collection of water fees is poor. There are thousands of water abstraction points to invoice and administer and many farmers do not accept that they should pay for water. Some are also too poor to pay even modest water fees.

Irrigation pumping costs in Souss are about US$0.085/CM. This increases to US$0.1-0.18 when well depreciation costs are included.

The cost of drilling wells varies from US$120-360/m depth of well.

5.4 International groundwater issues

There are no international groundwater issues with countries that border with Morocco.

6 Future perspective

The future demand for water will depend on population growth, socio-economic development, and also on climate change. Potable water demand is expected to increase by 60 percent to 620 MCM/yr by 2030, while agricultural demand is expected to rise by 20 percent -- in volumetic terms this represents an increase of 2,260 MCM/yr. The projected total deficit by 2030 is expected to be about 4,200 MCM/yr (Table 5). These figures do not include potential growth in private sector irrigation which is at present largely outside the control of the state. Groundwater is the main supply for private irrigation and as this is already over-exploited nationally by over 1,000 MCM/yr it is expected this situation can only worsen if there is no effective and rigorous control over groundwater abstraction.

The options available to close the gap between supply and demand include improvements in water use efficiency, particularly in irrigation where there are plans to introduce more than

450,000 ha of trickle irrigation; re-use of wastewater; the construction of new dams to further develop surface water supplies; new groundwater recharge schemes; and desalination of sea water, particularly to serve the urban population.

In April 2008 the Ministry of Agriculture announced the 'Green plan for Morocco' which sets out institutional reform for irrigation and has the potential to significantly improve the efficiency of irrigation water use.

• Table 5 Predicted groundwater balance for 2030

Regulated surface water	Exploitable groundwater	Water demand (2030)			Balance
		Domestic	Irrigation	Env	
8,230	2,575	1,615	13,210	180	-4,200

Source: Country Report

Climate change has yet to be factored into the planning process for water development. Suffice to say that the various expert reports predict increased temperatures with increased evaporation and reduced rainfall for the Near East and North Africa. These changes impact on agriculture and further increase the already excessive demands anticipated from the irrigation sector. Predictions suggest that the available water per capita could be reduced by 50 percent by 2050.

6.1 A new strategy for groundwater

Groundwater is seen as being democratic as far as access to water is concerned – the resource is well distributed across the country, and accessible by anyone who can dig or drill a well. In the past regulation was assured by local communities themselves and the limitations of exploitation methods meant that the sources was essentially renewable. The introduction of modern pumping and irrigation methods, the disruption of traditional society and the failure of government administration to step into the gap have led to the present situation of over-exploitation across the country.

In view of this there is now a move to establish a national safeguard programme for groundwater, which essentially aims to re-establish democratic and more equitable access to groundwater. This is supported by His Majesty the King who strongly supports the implementation of sustainable groundwater resource management.

The objective would be to reduce withdrawals by 1,000 MCM/yr. This would be achieved through savings in irrigation such as a gradual process of substitution of groundwater by wastewater reuse, especially close to urban areas; significant improvements in the regulation and policing of groundwater abstraction, improved knowledge of aquifers' safe yields, and more groundwater recharge schemes. In some cases it may be possible to substitute surface water and desalinated sea water along the coast for groundwater.

It is an ambitious plan and will require the cooperation of all the stakeholders who currently use groundwater. Some say the plan cannot work and is really not very ambitious. But 'business as usual' is also not feasible in the long term. So difficult choices will have to be made in the near future if some long term balance is to be struck between supply and demand.

Generally there is a lack of knowledge and understanding among water users about water availability and over-exploitation and the pollution of aquifers. This too will need to be rectified if all stakeholders are to participate in preserving groundwater supplies.

Although not specifically discussed in the Country Report, Morocco is looking to diversify its economy away from a dependency on agriculture in order to reduce the demand for water. This is being promoted at the highest levels in society by the King, the Prime Minister, and the Ministry of Finance all of whom have become champions of water reform. This is particularly to address non-water sector audiences on the impacts of poor water management across the economy.

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