Chapter 3. Morocco[1]

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Abstract

Morocco has well developed irrigation facilities that range from small scale communal systems based on springs, qanats or river diversions to groundwater-based individual initiatives and large scale public schemes. Water demand policies –e.g. water pricing, shift to drip irrigation, 'aquifer contracts' and other forms of participatory management– have shown little potential in curbing overexploitation of resources in many basins. Expansion of irrigated areas and the priority given to productivity have taken their toll on the environment, favored commercial agriculture, and contributed to a net depletion of groundwater estimated at one billion m^3/y. There is a need to better align agricultural development, water conservation, and environmental objectives.

After a short historical perspective, this chapter first reviews a number of trends in the irrigation sector (modernization, development of groundwater resources, wastewater reuse and desalination), before turning to regulatory and institutional issues, including participatory management, economic tools, privatization and an examination of the Plan Maroc Vert. The threats posed by climate change, water scarcity, and environmental degradation are then discussed.

Keywords: irrigation, policy, drip irrigation, climate change, water management, Morocco

1 Introduction

Because of the crucial importance of water resource in the development of the agricultural sector in Morocco, the history of irrigation policies during the 20th and 21st centuries largely overlaps with that of water policy in general. Morocco is one of the countries in the world which offers the largest diversity of irrigation schemes, in terms of types of water source, technology, scale of development, and actors involved in their management. For at least one century it has presented two main facets, often described as the 'duality' of agriculture, with on the one hand plots belonging to the rulers and their entourage, colons, elites, national or international investors, and on the other a peasant agriculture. While the former is generally developed on large farms by absentee owners, capital- and technology-intensive, fully irrigated, and identified as the 'modern' side of Moroccan agriculture, the latter is made of small holdings generally using less capital-intensive irrigation and agricultural production techniques (not to mention its much larger rain fed component). This chapter first briefly describes the historical steps of irrigation development in Morocco and its present status, before zooming in on recent technical and institutional changes instigated by state policies, but also the boom in groundwater abstraction. It underlines how the status of irrigation is eventually tightly linked to the overall (over)development of water resources in the country, and possibly threatened by agricultural policies that do not sufficiently consider environmental and hydrological constraints.

[1] Pre-print version of Chapter 3 In Molle, F.; Sanchis-Ibor, C. and Avella, L. (Eds), *Irrigation in the Mediterranean: Technologies, Institutions and Policies*. Global Issues in Water Policy Series. Springer.

2 Historical perspective on irrigation development

2.1 Water and land use in ancient times

In Morocco water use ingenuity has been driven by the relative aridity of the land and the know-how brought or developed by its successive civilizations (Benzekri 2006). Romans have developed urban water systems and their attendant transfer canals, while in the 9th century the Idriss dynasty further developed water supply in sanitation in the city of Fez. Technical innovations in the domain of agriculture are often associated with the qanat systems-locally called *khettaras*- that were introduced in the 12th century by the Almoravides, notably around Marrakech and in the Tafilalet. This technique was further developed by the Alaouites in the North, but also in oases (Benzekri 2006; El Faiz 2002). Believed to have originated in Persia and disseminated alongside Islamic expansion, khettaras tap superficial aquifers and act as 'artificial springs' serving communities, gardens and crops. They are notable both by the heavy investment in labour needed to excavate them (which often meant that either the state or a tribal collective would be undertaking their excavation) (Finet 2002; Pascon 1977), and by the sophisticated social rules that were developed to maintain them and manage the resource (El Faiz 2001).

The Almohade dynasty, while developing khettaras, turned to capturing superficial waters in *wadis* (generally intermittent stream) by means of *ougoug* (river weirs often made of earth, stones and branches) and earth diversion canals called *seguias*, that conveyed flood waters as well as low flows to irrigated lands. In the Marrakech plain (or *Haouz*), for example, farmers developed seguias between the 9th and the 12th century, diverting the rivers coming from the Atlas mountain valleys to their alluvial fans in the main valley (Cressier 2006). In the mid 20th century, they were irrigating 30,000 ha in the Haouz as well as serving Marrakech, diverting on average as much as 72% of the flow of the four main wadis feeding the Haouz (Pascon 1977). The 90 km long *Ya'qûbiyya* seguia linking the wadi Lakhdar basin to the Haouz plain is testimony of larger inter-basin transfers (El Faiz 2002). Accessing water was both a necessity and a manifestation of power, and the Soultaniya seguia illustrates how a 30 km long seguia could be placed upstream of all others and yet convey water to Marrakech across the land without being tampered with (Ennaji and Herzenni 1987; Cressier 2006). Other khettaras and seguias, and corresponding water rights, were controlled by zaouias (religious foundations) (Jolly 2002).

In the Middle and High Atlas, communities developed irrigation in the valleys by diverting local rivers. Water management was done collectively through the traditional organization of the *jmaa*. In general water rights are detached from land and can be lent or traded.

2.2 The French Protectorate (1912-1956)

Official colonization started in the Gharb plain in 1918, where large tracts of land were sold by the colonial administration to French entrepreneurs at "privileged conditions" (Le Coz 1968). This rich and fertile coastal plain characterized by semi-aquatic *merjas* (swampy land that needed to be reclaimed) "looked easy to settle due to the absence of permanent dwellers and was offering auspicious prospects for modern agriculture" (Le Coz 1968). Private colonization, whereby European settlers were buying land from Moroccan owners, started in the 1930s.

Colonial agriculture initially revolved around the cultivation of wheat due to the high prices on the French market reserved to this production as part of an indirect subsidy scheme (Amphoux 1933). But such a situation was precarious and many colons ended up indebted in the 1930s, prompting a search for diversification and cash crops. Between 1929 and 1933, several missions were sent to California to study agricultural expansion on the US Western coast. Because of their alleged climatic and geographic similarities, "Morocco was seen as resembling California at a time when the American West was a universal symbol of the modern world" (Bouderbala 1997). A new policy based on the development of irrigated agriculture and agricultural diversification came to be presented as

the solution to the failure of wheat production under rain-fed conditions, and as the lever that would allow the expansion and the success of colonization across Morocco.

Irrigation was brought in colonial development schemes under several forms. State policies first considered establishing private investors in large-scale public schemes, such as in the Gharb. In 1933, the construction of El Kansera dam was completed, together with the Beht irrigation scheme devoted to citrus cultivation, the export of which was strongly encouraged by the state. It also considered using traditional irrigation schemes like in the Haouz, to govern through local tribal leaders or notables (*caids*) and landowners who, together with the colons, occupied the largest and most fertile properties, monopolizing input, capital, and modern technologies of production (Pascon 1977). Last, in the Tadla scheme, the administration attempted to modernize the traditional agro-pastoral space, with the introduction of irrigation, seen by Marthelot (1961) as "the only undertaking which, before the end of the World War II, had aimed without restriction at modernizing a purely Moroccan rural population". Préfol (1986) emphasized that the aim of the administration in the Tadla "was the development of the land by its population and to its benefit, the objective being the modernization of life and mentalities" and marvelled at the "wonders of irrigation in Morocco". Agricultural activities, however, were defined and directed by the administration (the Office), which distributed tools, fertilizers and seeds, and ensured ploughing by tractors and the distribution of irrigation water (Préfol 1986). Pascon (1977) emphasized the loss of autonomy and social cohesion associated with the shift from community-managed irrigation to state-run networks and technology.

2.3 The post-independence period until 2012

Unlike other newly independent countries which sought their prosperity in industrialization, Morocco placed a lot of hope in agriculture and irrigation, partly because of the key influence in the *Istiqlal*, the then ruling party, of agronomists and engineers trained in the French *Grandes Ecoles* (Ihazrir 2009; Bourdillon and Faris 2004), and also because many of Istiqlal members were large landlords (Mouhsine and Lakmahri 2004).

2.3.1 The fate of colonial farms and agrarian reform

In the early 1960s, the government of Ibrahim Bouabid realized the failure of some early agricultural policies and programs such as the '*Ploughing Operation*', intensification programs based on improved seeds and fertilizers, etc. and decided to insert irrigation development in the new five-year plan of 1960-1964, which embodied new hopes for a restructuring of the traditional agricultural sector, most especially through massive investment in irrigation (Lazarev 2012; Swearingen 1987). This spurred the creation of the ONI (*Office National de l'Irrigation*) in 1960, as a response to the prevailing fragmentation of state agencies dealing with irrigation (Lazarev 2012). The ONI "was endowed with the largest development budget in the country, and enjoyed a degree of decision-making autonomy which largely insulated it from other government bodies" (Lazarev 2012). But the ONI was not interested in hydraulic development alone and put emphasis on agricultural and social policies. It embraced in particular the idea of an agrarian reform, with measures such as the expropriation of all colonial land and a limitation in the size of farms, which could redress the perverse effects of inequity in the access to land. Since labor and water were abundant, the ONI chose to design and develop irrigation schemes based on gravity irrigation techniques. "The measures proposed for the five-year plan in order to carry out an agrarian reform were judged to be too revolutionary (…) and they met with the opposition of King Mohammed V, of the Istiqlal party, and of landed elites" (Swearingen 1987).

Consequently, in 1962 the plan was abandoned and the ONI was absorbed by a new centralized Office (OMVA: Office de Mise en Valeur Agricole), in charge of land development across the country but soon decentralized at the regional level. At the national level, around 400,000 ha of a total of roughly one million colonial land were acquired by Moroccan through different types of transactions, while "the state distributed 326,100 ha of land through the agrarian reform, the remaining (300,000

ha or 270,000 ha, according to different sources) came to constitute state property (*domaine de l'Etat*)" (Mahdi 2014; Bessaoud 2013; Bouderbala 1999a).

The failure to implement a fully fledged distribution of earlier colonial land reflected the interest of the political elite in acquiring land for themselves, but also the priority given to productivity and the quest for profitability, which came to challenge earlier priorities given to social and equity considerations (Benali 2006). Policies further fuelled the duality of agriculture between, on the one hand, small peasants who received 5 ha plots and, on the other, an objective of intensification and profitability on state land (managed by two companies, SOGETA and SODEA) and large private landholdings which were largely preserved, especially in irrigated areas. At the end of the 1970s, for example, 1% of the landowners in the Haouz Plain controlled 38% of the land, while 62% of farmers owned only 12% of the land (Daoud 1981).

2.3.2 Dam building (La "Politique des barrages")

Because of the sheer difficulty to reform agrarian structures, the administration put social reforms on the back burner and concentrated on technical solutions, with King Hassan II announcing in 1967 his famous policy to develop one million hectares of irrigated land, rekindling an old colonial promise. This policy also endorsed the recommendations of a World Bank mission dispatched in the wake of the economic crisis of the mid 1060s, which recommended the concentration of investments on regions suitable for irrigation and to the benefit of the "most advanced farmers" (Swearingen 1987). The Hydraulics Directorate was created in the same year to shepherd the project, including large dams, canals and land development for irrigation schemes, and in the 1965-1972 period 50% of public investments went to the agricultural sector. Capitalizing on the peak of the price of phosphate in 1974 (which was one of the main sources of income for the state), the irrigation programme was launched in 1975: in the three-year plan of 1978-1980, 31% of public investments were devoted to rural and hydraulic infrastructures (Lazarev 2012).

But the hydraulic policy did not merely replace the agrarian reform. It was developed as an idea of its own. The new king, crowned in 1962, was bent upon making Morocco the 'California of Africa', with an agriculture based on an agro-export model (Ihazrir 2009), under the influence of the powerful corps of engineers (Akesbi 1988). "The monarchy […] after the passing away of Mohamed V in 1961, made an alliance with rural elites which ensured the success of the constitutional referendum in December 1962 and the (more controversial) parliamentary elections of April 1963" (Leveau 1998). Agriculture in general and dams/irrigation in particular became a political trump card, whereby the support of rural elites was sought by extending personal benefits to them in exchange for rural stability (Ihazir 2013), and were seen as essential to the stability of the regime (Akesbi and Guerraoui 1991; Leveau 1998; Regner 1975). Rural areas were considered as a major reserve of votes in support of the regime, which could be mobilized to check other political forces, such as left parties and labour unions.

While in 1969 the trade balance showed a surplus of 750 million dirham (DH)(~75 million euros), in 1974 the surplus had been replaced by a deficit of over 750 million DH (Swearingen 1987). For technical and political reasons, however, investments were not discontinued. Subject to riots and failed *coups d'état* attempts the country was still fragile and public investments continued based on borrowed capital. Between 1967 and 1975, the irrigated area grew by 24,000 ha annually (Benhadi 1975). This, however, rapidly proved to be unsustainable and in 1978 Morocco engaged into fiscal austerity policies. In addition, between 1978 and 1981 the price of oil came to be multiplied by 2.7, worsening the state fiscal deficit, resulting in a hike of basic foodstuff prices, and eventually widespread riots. In response, the state implemented austerity measures and launched a 5 year [1981-1985] economic recovery plan. On top of that, Morocco was affected by a severe and prolonged drought (1981-1984) which depleted available water resources (during the 1980/1985 period the stored volume hardly exceeded 25% of the total capacity), and fuelled outmigration from rural areas to the cities. This was the –untimely– moment in which structural adjustment packages

were imposed by the World Bank and the IMF, liberalizing the economy and rolling back the state well through the 1990s (Clément 1995).

A total of 12 dams were to be constructed between 1981 and 1985, but - with one exception- these dams were small compared to those constructed in the seventies. Yet, the initiation of the *Programme National de l'Irrigation* (PNI) in 1967, with the primary objective of bringing a total of one million hectares under irrigation before the year 2000, was reinforced by a 1986 declaration setting an objective of "one dam per year". Both goals were part of the Moroccan Government's longer-term strategy of "not one drop lost to the sea" (World Bank 1995) that would ten years later arouse the concerns of the World Bank that supply augmentation policies were reaching their limit (ibid.).

2.3.3 ORMVAs and the Agriculture Investment Code

Because of the considerable capital outlays mobilized by the Moroccan state to develop its irrigation sector, there was a need to ensure the profitability of these investments and the achievement of two major twin objectives: ensuring a degree of self-sufficiency in essential crops such like wheat, and promoting the export of cash crops. Guiding principles were encapsulated in the so-called '*Code des investissements agricoles*' issued in 1969, which principally concerned the irrigated sector. According to the Code, the state invests in large-scale irrigation schemes (managed by different ORMVAs: *Office Régional de Mise en Valeur Agricole*) and reserves itself the right to recover up to 40% of the investment costs from the beneficiaries (who do not need to be consulted prior to the investment) (Bouderbala et al. 1974; Bouderbala 1999b). The state is responsible for land reclamation and consolidation, land levelling and drainage. The beneficiaries must pay a lump sum of 1500 DH per ha per year and conform to the cropping patterns spelled out in the Code. In exchange, they may benefit from subsidized input, credit, and technical assistance. Collective land is allotted on the basis of 5 ha per beneficiary and land properties of less than 5 ha cannot be further parcelled. Land is earmarked for agriculture and cannot be turned into non-agricultural use.

Initially, the nine ORMVAs were not only responsible for water allocation and distribution but also determined cropping patterns, processed and marketed most industrial crops, including sugar, cereals, and cotton (Faysse et al. 2010). In addition, the State was strongly involved in the regulation of the market through prices setting and the implementation of development projects (Choukr-Allah 2004). Water distribution was rationalized based on cropping-patterns arranged according to pre-established patterns ('*trame A*' and '*trame B*') and fixed rotations (Pérennes 1993).

With time, this strong state involvement came under criticism. Fixed crops and water distribution patterns did not provide flexibility nor accommodated farmers' requirements or worries. Private initiative was reined in, recovery of service fees remained low, much maintenance was delayed, and the benefits expected by the state did not fully materialize (Benzekri 2006). The prohibition of land division below a threshold of 5 ha, meant to avoid land fragmentation, led to properties with multiple owners. Crop choice was eventually left to the farmers in 1985.

ORMVAs are in charge of constructing, maintaining (down to the tertiary level *included*), and managing infrastructures, but they also extend technical advice to farmers, while ensuring a water police function and recovering service fees. They are financially autonomous organizations placed under the Ministry of agriculture and administered by a board chaired by the Minister and mostly composed of representatives from the various administrations concerned.

2.3.4 Water law 10-95

Hitherto largely centered on water resource development for irrigation, the Moroccan water policy acquired a new face in 1995, with the Water Law 10-95. This law –the elaboration of which started as early as the early 1980s, during the drought period (Chaouni 2005)-, signals a shift away from exclusive supply augmentation and emphasizes demand management policies. Following the Dublin principles and the principles of Integrated Water Resources Management, the law puts forth the

user-pays and polluter-pays principles, and establishes decentralized River basin Organizations (*Agences de Basin Hydraulique*, ABH), while a National as well as Regional Environment Councils are created. The Water Law 10-95 also established the High Council for Water and Climate, which is supposed to define main water policy orientations at the national level, and provides for the coordination and the integration of water resources development and management policies at the level of each major River basin (Belghiti 2005).

The irrigation sector has been little affected by this law, and the prerogatives of the Ministry of Agriculture, in particular with regard to the ORMVAs, have been left largely untouched. Even in the recent Water Law 36-15 enacted in 2015, the Ministry of Agriculture has seemingly successfully negotiated its position (Tanouti 2017).

2.4 Current status of small-scale and large-scale irrigation systems

The irrigated area in Morocco has been estimated at 1.46 million hectares, that is around 17% of the total agricultural area of the country (8.7 million ha), to which can be added 300,000 ha of occasionally irrigated land in communal schemes (Belghiti 2005) (Table 1). Large-scale public irrigation, divided into nine ORMVAs, represents roughly 2 thirds of the perennially irrigated land in collective schemes.

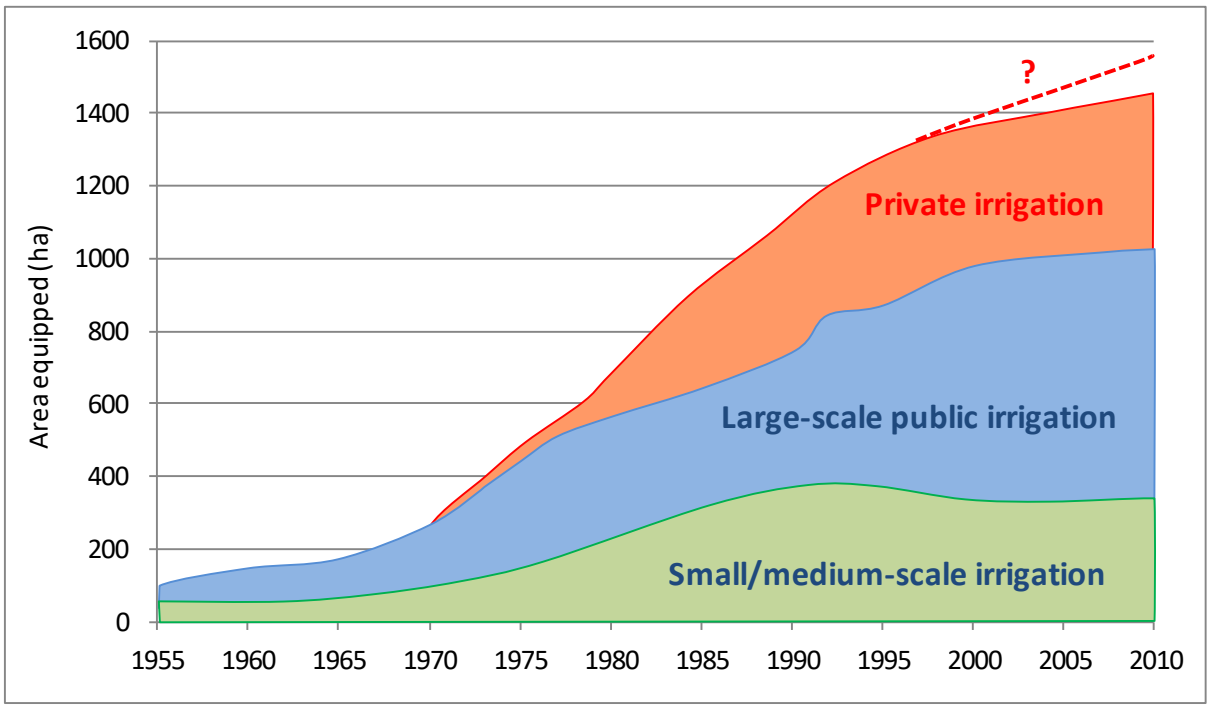
But this total area includes 441,430 ha of private irrigation, that is, irrigation developed based on groundwater and private wells. In reality, 626,610 ha belong to this category but 185,180 ha are located within large-scale public schemes and also use surface water. It must be noted that these figures are not very accurate because i) the area effectively irrigated is lower than the area equipped, ii) the area irrigated by seguias depends on water availability each year, and iii) there is no monitoring of groundwater-based irrigation. The 441,430 ha figure, as well as those of state irrigation, were already reported in 2004 (cited in Oubalkace 2007), and are still being used (see CESE 2014), showing that the continued expansion of this private irrigation is not well captured and not updated, and that private irrigation is probably underestimated (Figure 1).

The nine ORMVAs are shown on Figure 2, which also displays numerous dots showing small-and-medium scale irrigation schemes (PMH), mostly in or at the foot of the Atlas Mountains (and particularly in the mountain range between the Tensift and Souss river basins). Dark green dots show areas with intensive use of groundwater (principally coastal areas, the Saïss Plain, the Haouz and the Souss-Massa), but is also probably not fully up-to-date.

Table 1. Irrigated areas (ha), at the end of 2010 (MAPM 2012, 2013)

	Area (ha), by technology			
Type of irrigation	Gravity	Sprinkler	Drip	Total
Large-scale irrigation	504,459	110,760	67,381	682,600
Medium and small-scale irrigation	256,209	2610	75,311	334,130
Private irrigation	317,571	16,951	106,908	441,430
Total	107,8239	130,321	249,600	1458,160

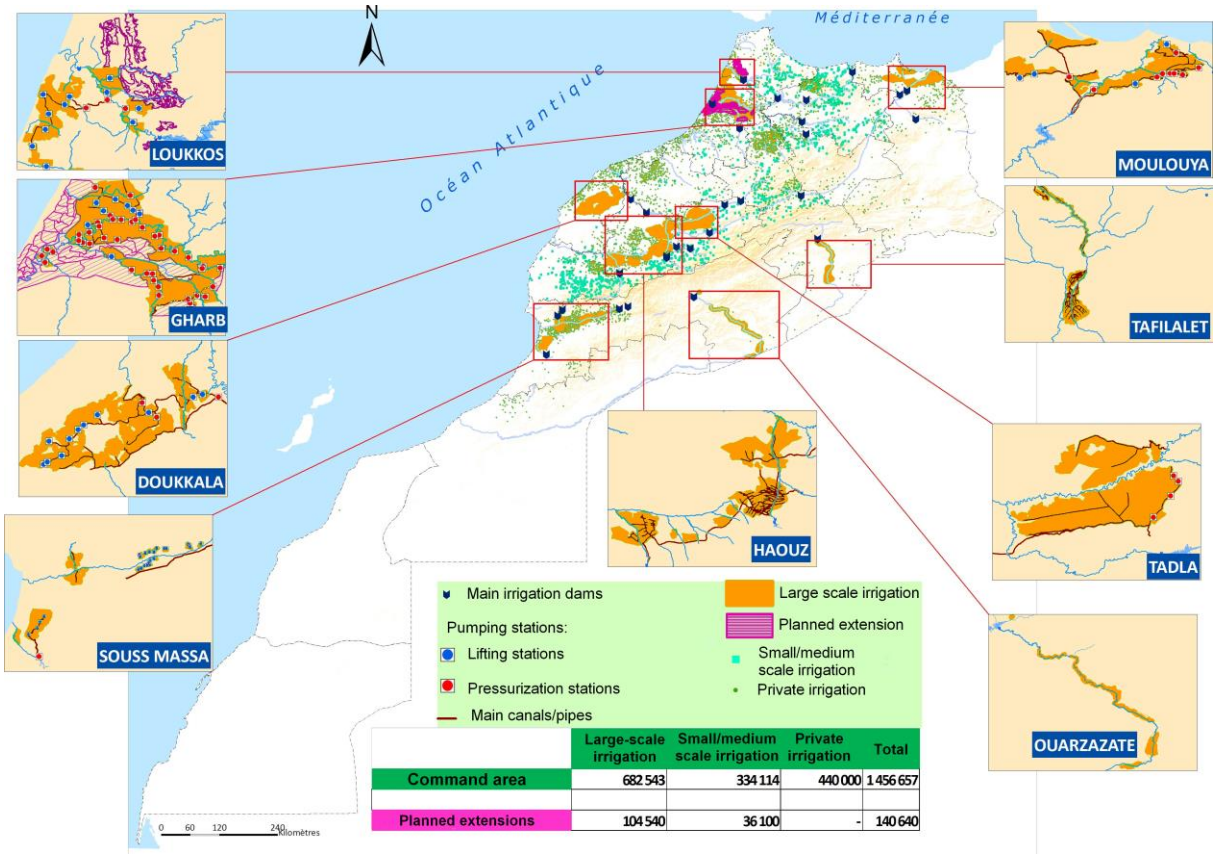
Figure 1. Evolution of areas equipped for irrigation.



Source: Various official reports; the area under private irrigation has been drawn approximately, based on intensive phases of well drilling reported during the dry years of the early 80s and early 90s, and the stated current area of 441,430 ha.

In general a provisional allocation is established each year by ORMVAs based on available supply (in the dams). Before each planned distribution period (typically every 2 to 4 weeks), individual farmers submit their request on whether they want to receive the quota they are entitled to. Then the ORMVA prepares the rotation schedule (starting and ending hours, and time derived from the ratio between target volume and flow rate (generally 30 l/s)), and then establishes the duration of supply to the corresponding tertiary. Farmers get a ticket with details about the supply to their fields planned for the following week, as does the ditch rider who distributes water within the tertiary. The system is somehow 'on demand' but requests are capped by the seasonal quota defined by ORMVAs and is *essentially a centralized system* (Plusquellec 2002). It must be noted, however, that the resulting volumetric monitoring of water use at the farm level is technically rather exceptional, as far as large-scale gravity irrigation is concerned. Sectors irrigated by sprinkler can be found in the Gharb, Loukkos and Doukkala.

Figure 2. Main irrigated areas in Morocco (adapted from MAPM 2012)



	Large-scale irrigation	Small/medium scale irrigation	Private irrigation	Total
Command area	682 543	334 114	440 000	1 456 657
Planned extensions	104 540	36 100	-	140 640

Because of uncertain/minimal deliveries and rigid rotations formerly adapted to centrally-imposed cropping patterns, diversification to crops such as vegetables (with frequent water requirements), has initially been constrained and this constraint has generally been bypassed by tapping groundwater (Kuper et al. 2012), or sometime through on-farm storage, either individual (investors) or collective (e.g. the Doukkala, see FAO 2012). Billing is generally done once (Haouz) or twice (Tadla) a year and the percentage of O&M fees collected is about 80 % (Van Vuren et al. 2004), except in the areas under sprinkler irrigation in the Gharb (and Loukkos) schemes, where recovery is very low because it is difficult for the ORVMA to stop individual farmers accessing collective irrigation hydrants.

Maintenance of ORMVAs' distribution networks, although often delayed, were addressed with substantial and recurring outlays of public funds channeled through successive rehabilitation programs, including the Large-scale irrigation rehabilitation project (PRGI) and the two World Bank-funded project on large-scale irrigation (PAGI 1 and 2)(Belghiti 2004). This financial burden has been the main motivation behind the calls for more user participation and the establishment of WUAs in the 1990s (see §4.2), water pricing (see §4.3) and later for the search for models of privatization which could render ORMVAs financially self-sufficient (see §4.5).

If in the 1970s all state resources and attention were directed towards large dams and irrigation schemes, from the 1980s onward the government turned to medium and small-scale (in general communal) irrigation (PMH), recognizing the historical importance of such traditional systems and the opportunities for 'modernizing' or rehabilitating them, or constructing new ones. This was done, in particular, through two World Bank loans (PMH-1 and PMH-2) (El Gueddari and Arrifi 2009). A total of around 1500 schemes covering 334,130 ha, largely managed by water users themselves, source their water from small dams, springs, *khetaras*, tube wells, and wadi weirs for spate or continuous irrigation. Gravity irrigation is the most widespread method (74% in 2010), while sprinkler irrigation

(10%) and most especially micro-irrigation (17%) are expanding with the recent *Plan Maroc Vert* (PMV)(SAM 2011).

Many khettaras and associated irrigation schemes have been particularly affected. In the Haouz, for example, the 500 khettaras have all dried up (in general because of the competition with wells) and/or been abandoned (due to very high maintenance costs or weakening of collective rules, and the urbanization process around Marrakech). In the oases, wells have often undermined khettaras systems (with some exceptions, like in Erfoud, near Ouarzazate, where well drilling has been reportedly been controlled by the community), but current irrigated areas have consistently increased with time. Out-migration and associated remittances have allowed investments back in irrigated agriculture, however unsustainable that may be (De Haas 2001).

3 Trends in the irrigation sector

3.1 The modernization of irrigation

Traditional gravity irrigation, and its practice in public schemes, has long been criticized for its alleged inefficiency and 'losses' (World Bank 1998). Moroccan policymakers have therefore extended substantial support to investments in micro-irrigation. Since 1982, taxes on the import of irrigation equipment or material have been reduced or cancelled (Laamari et al. 2011). In the 1990s, subsidies offered by the FDA (Agricultural Development Fund, established in 1986), averaged 17% of the investment costs in micro-irrigation. In 2002, a new decree raised the level of subsidies to 30%-40% and extended this subsidy to all components of the project (including wells, pumps, and intermediate storage ponds). Shortly after, a National Program for the Development of Micro-Irrigation was launched with a target of 114,000 ha. After five years this program had only achieved 39% of the stated objective (El Gueddari and Arrifi 2009), with 75% of the conversion observed actually achieved through the existing FDA. It must be noted, however, that these statistics do not consider farmers who have adopted drip out of their own choice and without subsidies (e.g. because they were not owner of the land), like in the Coastal Chaouia. Faced with the evidence that still few farmers had the capacity to invest, the government raised the rate of subsidies to 60% in 2006, and established in 2007 the National Program for Water Savings in Irrigation (PNEEI). Four years later, the PMV would finally raise the level of subsidies to 80% for large farms over 25 ha, and… 100% for small farmers. In less than 10 years the support to micro-irrigation shifted from a 17% to a 100% subsidy (though in practice, due to a maximal amount of subsidy defined for each component of the irrigation project, farmers often still have to pay part of the investment).

The PNEEI, subsumed into the PMV in 2008, adopted ambitious targets, seeking to achieve the conversion of 550,000 ha of land irrigated by gravity or sprinkler to drip irrigation, or in other terms to raise the percentage of micro-irrigation to 50% of the irrigated area in 15 years, at the cost of 37 billion DH. 72% of this conversion would concern large-scale public irrigation (including some individual farm conversions and the modernization of the collective distribution of water through pressurized pipes), with the remaining devoted to private individual irrigation. Technical change is supposed to be accompanied by technical advice on irrigation practices, crop choice, and linkages with the agro-industry and export markets.

The expected outcomes of the program include water savings varying between 30 and 50% (with a total of around one billion m^3 (Bm^3) 'saved'), an increase in yields up to 100%, increases in job creation, rural incomes, and service fee recovery, and -rather optimistically- the reduction of the energy demand of the irrigation sector as well as a reduction of the overexploitation of aquifers (El Gueddari and Arrifi 2009). The PNEEI is believed to be "conducive to a revolution in Moroccan irrigated agriculture, not only with regard to irrigation water use efficiency, but also to productivity and competitiveness" (ibid.). There is, however, a worrying overlooked point in the PNEEI. The 70 page official main document of the PNEEI only has two paragraphs stating that water efficiency is

scale sensitive and that losses at the plot level might not be losses when seen at the scale of the river basin. However, the rest of the document builds upon the ensuing statement "that it is at the level of the plot that water savings must be sought".

In Morocco, as elsewhere in the world, the rhetoric of water savings associated with micro-irrigation has been challenged by a growing body of evidence from the field, for example, the Haouz (Jobbins et al. 2015; Tanouti et al. 2016), the Souss (BRLi and Agroconcept 2013), or the Saïss (Benouniche et al. 2014). They emphasize the following issues:

- While the gross amount of water applied onto the plots is normally reduced by the technology, overirrigation with drip is common and studies in 4 different settings have shown plot-level efficiencies varying between 25 and 90% (Benouniche et al. 2014), due to farmers' lack of interest in delivering only the needed amount of water, a lack of know-how, poor system design, or technical problems such as clogging.
- With the shift to drip, farmers often choose to 'densify' their orchard or olive grove by adding (young) trees in the middle of old trees, adopting mixed-cropping (e.g. adding fruit tree lines between olive trees), or planting his plot anew with a higher density of trees (either olive or fruit). Vegetables and trees are clearly associated with drip and generally increase water requirements (and consumption) (Kuper et al. 2012).
- Even if the amount of water applied is reduced (and the same crop is maintained), it is uncertain whether the overall *net consumption* of water is reduced since reduction in non-beneficial soil evaporation is compensated by an increase in crop transpiration.
- Since drip systems are most frequently associated with individual wells, the water available is defined by the capacity of the well and is therefore not changed in the short term. With reduced application per unit of land, the farmer will be led to expand laterally to increase his irrigated area into plots that are either rainfed or left fallow because of insufficient supply, whether these plots are his own or rented from neighbors.

In other words, private benefits (increased yields and farm incomes) arise in tandem with a huge environmental cost: the depletion (or net consumption through evapotranspiration) of more water, which in the vast majority of the cases (most notably the southern deficit basins) translates into *further depletion of the aquifers*. Indeed, if supply of surface water is maintained, or even reduced, on the one hand, and water consumption enhanced, on the other, then the difference can *only come* from reduced return flows (to rivers or, mostly, aquifers).

This 'rebound effect', whereby drip irrigation translates into more water being consumed, while reducing the recharge of (already overexploited) aquifers, has now been well identified (Molle and Tanouti 2017). In Morocco the PMV or the PNEEI only have passing references to these problems and the risk of the "acceleration of the exploitation of aquifers" is said to be minimized "through the promotion of a rational practice of micro-irrigation and also through the establishment of aquifer contracts by the River basin agencies with which collaboration will be sought" (MAPM 2007a). Other parallel measures that this document promotes include an exhaustive inventory of wells, to be complemented by a survey on actual abstraction, awareness raising campaigns about the risks associated with overexploitation, and the installation of meters for all groundwater users, "a very tricky but totally indispensable measure to be implemented" (ibid.).

Last, the PMV/PNEEI carry with them the risk, identified by the Ministry (MAPM 2007a), of a poor technical or financial performance which would lead farmers to blame the new irrigation technology and revert to former practices. This risk is all the more real due to the fact that farmers are enticed by technology sellers to apply for these 100% subsidized projects, and also because market prices are uncertain and can slump due to local overproduction or external causes (e.g. the recent drop in the price of citrus or tomato).

3.2 The groundwater rush

3.2.1 Situation, drivers, regulations

From the 1970s onwards, but more strongly in the past 20 years, groundwater use for irrigation has developed quickly in Morocco. This has primarily been the case within the ORMVAs, where the failure to deliver adequate quantities of irrigation water has prompted farmers to tap the aquifer underneath their feet, which is largely replenished by the infiltration generated by the irrigation process. This trend was accentuated during the drought of the early 1980s. In the Tadla scheme, for example, the number of wells rocketed up from 900 in 1980 to 8,735 in 1984 (Hammami et al. 2004). A second type of groundwater-based irrigation developed in the vicinity of ORMVAs' schemes (Haouz, Doukala, Gharb, Loukkos…), but also in partly-irrigated large plains like the Saïss, and generally uncultivated or rainfed areas (Guerdane, Chichaoua, etc). Small or big farmers sometimes follow a kind of mining strategy. Some investors from the Souss, for example, who had seen their groundwater resources exhausted, moved up north to the Chichaoua region (Tensift basin) to drill new wells, and then moved further afield to the Saïss Plain, when water levels dropped.

Because of the drought situation in the early 1980s (and later in the early 1990s) and the relief it provides, well drilling was initially subsidized by the state. In 1984, taxes on the import of drilling rigs and material were canceled and the drilling of wells, electrification, and irrigation material started to be subsidized (Laamari et al. 2011). The drilling of tubewells was boosted by the advent of Syrian drillers who spread over the whole Arab world with deep-drilling technical know-how (Quarouch et al. 2014). But it also benefited from a very lose enforcement of the law according to which water abstraction above a certain quantity requires an authorization. The 1995 Water Law reinforced the necessity to go through a licensing procedure for all kinds of water abstraction from the public domain (surface and groundwater). ORMVAs were in charge of licensing in their areas of responsibility. With the advent of the ABHs this responsibility shifted to the agencies but a negotiation took place whereby the ORMVAs remained responsible for drilling authorizations in the areas under their responsibility, while ABHs would grant water use permits. This double line of command introduced confusion and competition, and the possibility for the Ministry of agriculture to bypass restrictions associated with the overexploitation of aquifers and to promote the drilling of new wells as part of the PMV, against the will and the regulatory role of the Ministry of water and ABHs (Tanouti 2017).

Registration and licensing are part of the panoply of management tools. In Morocco a decree indicated in 1997 that water withdrawals points established before the enactment of the 1995 Law should be declared to the ABHs within a timeframe of one year after the publication of the decree. Because of the lack of responsiveness from users, two extensions of that registration period have been granted until October 2015, after which date no other extension of the delay would be granted and violators would face penalties of up to 2000 DH (BRLi and Agroconcept 2013; L'Economiste 2015). All wells drilled before April 2009 are in a position to be legalized. Wells drilled after this date are considered illegal, unless their owners have requested and received an authorization. The lack of interest shown by farmers can be explained by a burdensome procedure, and the (largely theoretical) condition to install a meter at their cost (the price of which varies between 1500 and 2000 DH for small farms and reaches 20,000 DH for large farms). In addition, the owner of the well must declare his consumption once a year and pay a water bill based on the rate of 0.02 DH/m^3 (L'Economiste 2015). It is only after well registration became a condition for accessing the generous subsidies of the PMV that farmers interested in the PMV showed willingness to officialize their well.

There is currently no reliable inventory of (agricultural) wells and boreholes in Morocco. In the Souss-Massa-Draâ basin, the system of authorizations is widely disregarded and out of an estimated 17000 existing wells, only 2000 have been authorized (L'Economiste 2014). The ABH of Tensift has inventoried (circa 2010) 10,700 wells and boreholes and estimates the percentage of illegal wells at

31%, making up a total of around 14,000 wells and boreholes in the Haouz; but according to one official the real number is more likely to be around 25,000.

Calls by the Economic, Social and Environmental Council (CESE 2014) for the "installation of water meters on all tubewells of small, medium and large farms and combating illegal water abstraction for irrigation", or the intention of the PNEEI to install meters on all abstraction points, do not realize the difficulty of the task and, at this stage, are tantamount to wishful thinking. The installation of water meters is obligatory to get access to PMV subsidies, but field visits are limited and no follow-up is in order (BRLi and Agroconcept 2013). Sanctioning and the water police are reportedly weak to nonexistent (MAPM 2007a; CESE 2014; Del Vecchio 2013). Because of the strong and effective presence of the control of the Ministry of Interior at the local level (through *caids* and *moqaddems*), it can be inferred that slack policing reflects a lack of political will rather than a lack of means.

The 1995 Water Law also provides for mechanisms that should be activated in case of overexploitation of resources, such as safeguard or prohibition area delineation. However, Morocco has surprisingly never resorted to these plans of action, even though some ABHs have requested them. Given a groundwater overdraft estimated at 1 Bm^3 per year by the Minister of Water (Maroc.ma 2014), and the situation of overexploitation of all major aquifers in the country (Monitor Group 2008), it is hard to escape the conclusion that the political influence of interests associated with the expansion of groundwater-based agriculture has so far prevailed upon conservation policies.

However, current groundwater use is associated with growing negative externalities and clearly unsustainable. All the measures envisaged – registration, tariffs, micro-irrigation or, according to the Minister of Water, "the adoption of a new mode of governance that promotes participatory approaches, through 'aquifer contracts', involving all the stakeholders in decision-making" (Maroc.ma 2014) – are unlikely to stem the overdraft and not up to the challenges posed (Molle 2017). The main measure actually implemented –surface water supply augmentation through transfers– (e.g. Souss, coastal Chaouia, Saïss) will only provide some respite while fuelling more expansion of irrigated land.

3.2.2 The groundwater management contracts

The experience in Morocco with aquifer comanagement, later called '*contrats de nappes*' (aquifer contracts), started in 2004 when the Souss Massa ABH carried out an awareness campaign about the new water law and proceeded to close illegal wells. This triggered social unrest and the Governor of the region suspended the decision and decided to approach the problem by creating a commission integrating representatives from 20 institutional partners. An agreement was signed in 2007 which included (among other things) 22 small dams and 5 large dams to be constructed by the state, and a regularization of 'illegal' wells, against a freezing of the expansion of irrigated areas for citrus and vegetables, a (subsidized) shift to drip irrigation, an increase of groundwater user fees, and a reinforcement of the water police (Faysse et al. 2012). Eight years after the signing of the agreement the situation has not really changed, as the contract has been undermined by a general laisser-faire attitude, the failure of the government to deliver on the supply augmentation projects and enforce regulations, and the event of a few good hydrologic years that have displaced the prevailing sense of urgency.

Although the aquifer contract in the Souss was not implemented, around 2011 the GIZ started supporting the ABH of Souss-Massa, Tensift and Tadla (GIZ 2011), with an overoptimistic planning of multi-stakeholder meetings expected to lead to an agreement on a convention after one year. These initiatives bumped into the technical, institutional and political complexity of the problem addressed and were not conclusive. In 2013 an inter-ministerial notification signed by the Ministries of Agriculture, of the Interior, and of Water, expressed political support to the establishment of aquifer contracts and clarified the procedure to be adopted.

In 2014, a national workshop on the management of groundwater resources put the aquifer contracts centre stage again (Tanouti 2017). The Minister for water acknowledged the failure of the control of groundwater abstraction, a problem which neither the law nor the 2009 National Water Strategy could successfully address, pointing to "a legal vacuum" with regard to aquifer contracts, and to some "reluctance among the partners of the Department in charge". Yet, the Ministry presented at the workshop a timetable of 15 major aquifer contracts, all slated to start before the end of 2016. The four components of these aquifer contracts, however, pointed to a rather top-down approach largely consisting of constraining measures (Molle 2017).

The 'aquifer contract' for the Saïss Plain, for example, mainly restates the measures spelled out in the basin masterplan (PDAIRE), does not declare the Saïss as a safeguard zone, and contains no provision for controlling the use of private wells and tubewells, or the participation of users, prompting Del Vecchio (2013) to comment that the aquifer contract is in reality "essentially a hydraulic and agricultural development policy characterized by a strong interventionism of the Moroccan state". The jury's still out as to whether this is a promising way forward but the failure of the Souss-Massa contract, the first aborted attempts in the Tadla or Haouz, and the current framing of the Saïss aquifer contract do not provide ground for much optimism. The very high number of farmers using groundwater for irrigation in an uncoordinated and largely informal manner outlines a challenging setting. Yet, in 2014 the government declared a policy to have such contracts established in all major aquifers (later reduced to three) in Morocco by 2016 (L'Economiste 2014), further to a loan conditionality set up by the World Bank.

3.3 Reusing wastewater for irrigation

The amount of wastewater generated by Moroccan cities has increased from 48 in 1960, to 500 Mm^3 in 2000, and 700 Mm^3 in 2010 (Aomar and Abdelmajid 2002; MAPM 2011). Morocco has been very slow to consider developing reuse as a means of increasing water supply. Farmers however often did not wait to make use of this resource and more than 7000 ha were reported to be irrigated with raw sewage in 2000 (ibid.), while about 546 Mm^3 of raw wastewater was discharged to the environment (60% of which to the sea). A few pilot projects have been developed in the 1990s near Agadir (aerated lagoon and filtration/percolation) or Ouarzazate (lagooning). Another project started in 2003 in Attaouia (El Kelâa des Sraghna). A national plan for the treatment of wastewater has been launched in 2005 with the aim of treating all wastewater by 2030. The National strategy of 2009 later set a lower target of 300 Mm^3 of treated wastewater to be reused by 2030 for the irrigation of golf courses, public gardens or crops.

One of these new projects is being implemented in Marrakech and is hitting the headline. The treatment station has a capacity to treat 110,000 m^3/day at the secondary level of treatment. Treated water is to be used for the irrigation of golf courses as well as to revive part of the famed palm tree grove of the city. The project has been advertised as epitomizing new environmental policies as well as conservation strategies in the face of water scarcity. While the analysis of the project's technical and financial difficulties point to a complex relationship between the state and private investors (Ennabih 2016), another aspect deserves emphasis: it appears that Marrakech's wastewater was already used by local farmers to irrigate an area of approximately 2000 ha. The project is therefore also tantamount to a reallocation of the resource from local farmers to golf courses (Tanouti and Molle 2013). Everywhere else in Morocco, wastewater is actually used by farmers, irrespective of regulations.

3.4 Desalination

Desalination is another option offered to Moroccan planners. Because of the cost of producing water it is more suitable for the production of potable water for coastal cities but it is also being contemplated as a means of substituting groundwater in the Chtouka area (in the Massa basin in the south), where the aquifer is being depleted. An elaborate Public-Private Partnership (PPP) is under

planning, whereby an area of 12,000 ha would be supplied with desalinated seawater by a private company under the conditions that the larger landholders commit to buying this (expensive) water, and that the community of users helps freeze the expansion of wells. But desalinated water might also constitute a cost-effective solution in oasis areas, when coupled with solar energy and niche market opportunities (Benabderraziq 2017).

4 Institutional, regulatory and policy frameworks

4.1 Formal organization of the irrigation sector

From an institutional point of view, the creation of water/environmental administrations by the Water Law 10-95 came with the setting up of ABHs, and a reorganization of the water sector and the abolishment of the Regional Hydraulic Directorates (Directions Régionales de l'Hydraulique, or DRH) whose staff, however, has been largely transferred to the ABHs (Tanouti 2017)[2]. The new structuring implied a substantial redistribution of roles and bureaucratic prerogatives. ABHs are supposed to take care of data collection, water abstraction authorizations, basin level planning (through the establishing of basin master plans called PDAIRE), and the yearly allocation of dam water. In theory, ABHs should regulate demand according to the available supply, integrate the different uses, including the environment, and promote participatory management. However, the central state clearly keeps a strong control over the ABHs and is predominant in its administration board, chaired by the minister in charge of water resources and consisting of 60% of members representing state agencies (Tardieu 2001). In addition, the establishment of ABHs has been slow (seven years to establish them in most basins, and 14 years to extend ABH to the whole territory).

Expectedly, these new prerogatives located under the Ministry/Secretary of Environment have been seen by traditional central administrations, most especially the Ministry of Agriculture and its ORMVAs, as a "challenge to their power" (Tardieu 2001; Tanouti 2017). This is in particular true because the ABHs have taken over decisions about allocation of water at the basin level, which means that ORMVAs have become bulk water users among others and, although they still yield substantial negotiation power, do not decide anymore on the amounts of water to be released by the dams. Yet, the culture of planning and building infrastructure has largely been passed to the new structure, since the ABHs have frequently been sited in the quarters of the former DRH (de Miras and Le Tellier 2005), while the DRH staff have "accepted the transfer without renouncing to their past" (Tazi Sediq 2006). For cultural and political reasons, their 'regulatory' power intended remains weak.

Part of the budget of the ABHs comes from a water tax levied on industrial users and irrigators. The tax for using public domain resources has been fixed at 0,02 DH/m^3, and is passed on to the ABH by the ORMVAs which collect fees from farmers. ABH should also theoretically levy taxes from polluters

[2] In the 1970s, the irrigation sector was focused on developing infrastructures and placed under the Ministry of Agriculture and Agrarian reform, with a Water Resource Development Directorate (*Direction de Mise en valeur*) that would include the ONI and the OMVA. It was later replaced by the Rural Engineering Administration, with two directorates responsible for the development of public irrigation infrastructure and the O&M of ORMVAs, respectively. But in parallel, the General Administration for Hydraulic Works –under the Ministry of Public Works–, and its regional branches (DRH), was responsible for other hydraulic infrastructures, notably dams. In 1994, two years after the Rio submit, a Secretary of State in charge of the environment is placed under the Ministry of Interior, but one year later the environment is put under the responsibility of a fully-fledged Ministry of the Environment. This Ministry will however be short-lived and subsumed two years later into the Ministry of Agriculture, Public Works, and Environment, under the powerful civil engineer Mziane Belfqih. One year later, in 1998, with the advent of a socialist government, the administration in charge of the environment was again shifted to a Ministry of Rural and Urban Planning, and Environment. In 2002 the ABHs were emancipated from this Ministry and placed under a new Ministry of Development Use Planning, Water and Environment. This new ministry placed water outside the Ministry of Agriculture, the Ministry of Interior and the Ministry of Public Works, but this relative independence was short-lived and in 2007 it was conflated with the Ministry of energy, mines, water and the environment, and placed under a Secretary of State in charge of Water and Environment. Last, in 2012, these two responsibilities were separated and each of them entrusted to a *Ministre délégué*.

but the polluter pays principle is not implemented yet. Theoretically, in line with the French model, the sums recovered should be transformed into subsidies to water conservation or treatment actions (Belghiti 2005).

Neither the irrigation sector nor the development of hydraulic infrastructure have been much challenged by the administration in charge of the environment which is currently, tellingly, lumped together with the sectors of mines, water and energy, as indicated earlier. In Section 5.1 we will return to commenting on sectoral policy contradictions and on how agriculture in general and irrigation in particular remain largely unaffected by environmental regulation. Despite a water law often lauded as a state-of-the-art legislation, some analysts consider that "Legislative and regulatory work and institutional development [have] led, respectively, to a compilation of fragmentary texts with a number of loopholes and inconsistencies, and to a juxtaposition of sectoral institutions and missions constituting a heavy and costly technical-administrative apparatus" (El Alaoui 2006).

4.2 Stakeholders' participation: conflicting views and practices

The large-scale irrigation schemes developed between the 1950s and the 1980s have been put under strong centralized management. After the adoption of structural adjustment policies in 1983 and economic liberalization, the government withdrew from agricultural and marketing activities, raised water fees, and –much to the insistence of the World Bank- started to explicitly call for the involvement of users in water management (van Vuren et al. 2004; Bergh 2007). The government introduced a Participatory Irrigation Management (PIM) policy and in 1990 passed Law 02-84 that specified the legal status of WUA and named them *Association d'Usagers de l'Eau Agricole* (AUEA). The 1992 Decree 2-84-106 that established the terms of agreement between the government and the AUEAs reads like a detailed list of the duties and incumbencies these associations have to comply with, with hardly any mention of the benefits they would get in return. The law specifies that an agreement must be signed with the state, expressing "*the commitment of the association to mobilize the funds needed to cover all the expenditures associated with the administration of the association, water distribution, and the maintenance and conservation of infrastructures (…) and the obligation to carry out regularly the maintenance works needed to keep all facilities in good working conditions".*

An elected board implements the decisions taken by the general assembly, establishes budgets and submits them to the assembly, and can hire staff (Freitas 1996). The democratic nature of elections is affected by the high rate of illiteracy of farmers, with more than 70 % of them found illiterate in the case of the Tadla scheme (van Vuren et al. 2004). A degree of control over WUAs is exerted through the nomination of the 7th board member (dubbed '*the seventh man*') by the Administration, as a representative of the Ministry of Agriculture, while Article 15 stipulates that other representatives of the government can have advisory roles if they wish so. The official reason for this dispositive is to facilitate communication with the government, but in practice, it is often used as a means of imposing governmental decisions. WUAs are also constrained by their stated attributions: some WUAs started to supply water to farmers located outside the official irrigation system, while charging them higher fees, but this practice remains informal and even illegal (Errahj et al. 2009). The lack of political will to empower farmers (Faysse et al. 2010) is well illustrated by the authorities' indecisiveness to grant WUAs financial independence (van Vuren et al. 2004): in the Tadla scheme WUAs were first established with budgets constituted by the 20% of collected fees handed back to them. However, this transfer was later cancelled because it was found to be in contradiction with the Code of Agricultural Investments (Doukkali 2005).

"As had been the case in the past, the government took the initiative, defined the rules of the game in its own way, and maintained the right of oversight of the associations operations" (Belghiti 2005). These policies did not yield significant changes in governance and most of the 408 WUAs officially found in large-scale irrigation schemes remain apathetic or non-existent (Aloussi and Anbari 2012), especially in the Doukkala, Gharb and Loukkos schemes (Faysse et al. 2010). In the Tadla, Van Vuren

et al. (2004) identified a lack of political will for an effective transfer of irrigation management, and noted that "the staff from the ORMVAT does not want to lose its position as irrigation manager"[3].

From the 2000s onwards, the state started an ambitious policy to shift from surface and sprinkler irrigation in large-scale schemes to drip irrigation. The PAGI project, the *Programme d'Amélioration de la Grande Hydraulique* funded by the World Bank, was conditional upon the establishment of WUAs. This was done on paper but most of these WUAs remained dysfunctional or non-existent, partly because of the non-implication of farmers in the design of both infrastructural and institutional interventions[4], partly because of the lack of interest from managers unwilling to relinquish their roles and prerogatives (Mahdi 2012; Kadiri and Mahdi 2013). ORMVAs attempted to "revitalize" the WUAs, so that they could play a key role in the coordination between farmers and the irrigation office during the modernization process, however the lack of means of WUAs limited their capacity to play such a role (Hadioui et al. 2014). The case of the N'fis scheme, near Marrakech, showed that farmers' commitment to participate in water management through WUAs was very weak. Farmers did not ask for the establishment of the associations, were not involved in their formation, and in the manner through which they were grouped under a particular WUA (Keita 2006; Raki and Ruf 2006; Valony 2006). More recently, however, some WUAs in the Tadla scheme, which had been inactive for years, were revived when a younger and more informed generation became involved in irrigation management (Faysse et al. 2010).

WUAs have been more successful in small-scale irrigation schemes that were already managed by farmers (Bekkari and Castillo 2011). In the Aït Hakim and Aït Bouguemez valleys, for example, sophisticated and flexible water sharing arrangements were formalized, with different upstream and downstream irrigation rules, and also different village-level rules (Keita 2006; Romagny and Riaux 2007). In many cases, however, traditional management did not require the establishment of WUAs and WUAs were merely pre-conditions for the World Bank (Programmes SMIS 1 and 2) and other donors to have identified beneficiary groups before releasing funding (Mehdi 2012; Riaux). Yet Bergh (2007) showed that lack of openness in the preparation of development plans and planning phases, as well as project implementation, was a main impediment to the successful execution of IMT/PIM programmes.

But new institutions may also be a window of opportunity for some local actors to change the *status quo*. Kadiri et al. (2009) showed also that the competitive recruitment of young graduates played an important role in the improvement of management in the *Moyen Sébou* irrigation scheme in Morocco. They simplified administrative procedures, adapted the rules in place when needed, and reacted more quickly to emergencies (breakdowns of canals, pumps).

4.3 Economic issues and tools

According to the 1969 Investment Code, the contribution of beneficiaries to irrigation investment costs was established at 1500 DH/ha, and later raised in 1984 to 30% of the average irrigation investment costs. Until 1997, this contribution was waived for farms under 5 ha, and for the first 5 ha of farms under 20 ha, while payment was staggered over 17 years, with a 4% interest rate. In 1997 the contribution was raised to 40% for all farms, and the interest rate fixed at 6% (Belghiti 2004). Although eventually moderate, the percentage of investment costs recovered is rather high when seen comparatively at the world level (Molle and Berkoff 2007a).

[3] Likewise, Bergh (2007) identified a problem with the "purely technical and depoliticized view of participation that dominates the attitudes of Moroccan civil servants… The deeper origin of such attitudes lies in the central government's reluctance to open up the spaces that are necessary for a more political sense of agency to develop. The latter would in turn allow participation to unfold as a truly transformative power for rural development".

[4] Belghiti (2005) acknowledges that "the integration of human dimension in the design of the projects makes them sometimes more difficult and costly in time and effort because it is complicated in term of choice of standards design and of process of implementing".

Since the establishment of the nine ORMVAs, a major concern of the state has been their physical and financial sustainability. Delayed maintenance prompted two large World Bank loans (PAGI 1 and 2, in the 1983-2000 period) to avoid the degradation of the investments. The World Bank developed at 'Bulk water pricing study' as part of it 1998-2004 'Morocco Water Resources Management Project', that clearly spelled out the costs of the water service and the ability to pay of farmers (Belghiti 2004). Morocco was obliged to raise its level of cost recovery several times, first as part of the Structural Adjustment Plan during 1980-1984, then of the World Bank (PAGI) project during the 1997-2006 period, and finally of an European grant conditionality (FAS-EAU), after 2007 (MAPM 2007a, Belghiti 2004).

The financial contribution of farmers might not be sufficient to cover all O&M costs but it is quite substantial, especially when compared with other countries in the MENA region, notably in the ORMVAs which have water lifting costs. The rate of recovery of the service fee is also high in gravity irrigation schemes (much less so for sprinkler irrigation), since water supply is often on demand and ORMVAs can –technically- easily exclude farmers who do not pay their fees. ORMVAs combine three mandates (studies and development, O&M, extension services) and the service fees (around 0.35 DH/m^3) actually cross-subsidize other functions that should be covered by the state budget. More recently, management costs have come to also include the ABHs, as "the main part of their budget has to come from water users" (World Bank 2009). In any case, raising prices to the level of covering management costs has proved to be problematic. For Doukkali (2005), "the inability to complete water pricing reforms, clearly suggests how political costs have overshadowed the real socio-economic and resource costs".

Irrigation water pricing has also long been advocated by the World Bank and mainstream organizations, based on the idea that to cope with water scarcity, "full recovery of the cost of irrigation water and the integrated management of the resource would lead to significant gains in efficiency and encourage a shift to crops requiring less water" (OED 1998). ORMVAs hardly cover half of irrigation needs and there is therefore no 'wastage' from which one could expect farmers to reduce their 'demand'. The marginal value of this water in terms of production is way higher than its cost to the farmers, and this would still be the case even if the full O&M costs were recovered from them. It is well recognized that too high prices would also push farmers to shift to groundwater (ORMVAs' water is priced at 0.35dh/m^3 against 0.02dh/m^3, for a lump volume of 3000 m^3/ha), when aquifers are not too deep or when groundwater is not saline (Monitor Group 2008; Belghiti 2004). This is what many already do, not for reducing costs but because groundwater is available on-demand and escapes the rigidity of irrigation rotations.

Water pricing has also resurfaced, however timidly, as one of the measures listed to help combat the overexploitation of aquifers by individual users. At the moment an extremely limited percentage of farms pay for the groundwater they abstract, as mandated by the Law. The National Water Strategy briefly mentions the need to "adopt a water pricing system based on volumetric metering" (Royaume du Maroc 2011). The Monitor Group (2008) considers that water pricing is a 'lever' with a "high level of influence" on demand, and proposes to increase the price of groundwater, and also to establish a premium (higher) price for water abstracted in overexploited aquifers.

At the same time, policies are silent about the more politically sensitive issue of energy subsidies, notably about how domestic gas (that came to be cheaper than diesel) is now largely used for groundwater pumping. By envisioning a volumetric pricing system, policy-makers also make it conditional upon the identification of existing wells and the thorny prerequisite that the use of each farmer should be volumetrically known.

4.4 The "Green Morocco Plan" and irrigation

The Green Morocco Plan (*Plan Maroc Vert*, or PMV) is a sector-wide comprehensive agricultural development plan launched in 2008 with ambitious objectives (a contribution to GDP of 174 Billion

DH, the creation of 1.15 million jobs by 2020, the tripling of the income of 3 million people in rural areas). It rests on two pillars: the accelerated development of a modern and competitive agriculture, with regard to both production and food processing; and the support to smallholder agriculture through the implementation or professionalization of 545 projects of small farms in poorer rural areas. These two pillars are to be strengthened by a number of cross-sector reforms concerning water and land tenure, and an original mechanism called 'aggregation', whereby small and fragmented landholdings are expected to access technology and markets through an association with more advanced and capital-intensive actors. With regard to water and irrigation, ongoing projects from the Ministry of Agriculture have been subsumed into the PMV, conceived as an overarching programme (Belghiti 2010). This concerned not only the PNEEI but also the "Programme to bridge the gap between dams and irrigated areas", that aimed at completing the development of irrigated areas originally planned under the main dams on the country (140,000 ha over 10 years); and the PPP "for the delegation of public irrigation service" (see next section).

Section 3.1 has already discussed the impact of the PNEEI (now under PMV) on water resources, mostly aquifers, because of the overall likely increase in water consumption associated with the conversion to drip irrigation. The PMV set out to shift the level of support to the conversion to drip irrigation to 100%, to offset any reluctance from farmers due to financial considerations[5]. But the PMV does not only aim at the conversion of gravity irrigation into drip. It also includes the expansion of irrigated agriculture. This is constrained by the need for farmers or investors to show a legal land title and well permits if they want to benefit from the subsidies. While farmers had largely ignored previous regularization campaigns, in the 2010s the windfall subsidies of the PMV made the number of applications soar and the authorizations for abstracting groundwater were initially given with few exceptions. To bypass the growing reluctance of ABHs to give permits, the PMV offered loopholes to farmers so that drip irrigation projects and their subsidies could go ahead. The PMV allowed farmers to apply for reconversion subsidies if they signed a letter certifying that they were using the well before 2005 (Saïss), or exhibited an administrative document showing they have initiated an administrative request to regularize an allegedly old well (Haouz)(del Vecchio 2013; Tanouti 2017). Illegal, but also legal, well drilling is still possible either through personal arrangements with local authorities, or through the intervention of powerful people in the government or political system. There is clear evidence of investors using influence to get well authorizations for developing plantations on (collective tribal) land leased by the Ministry of Interior, on the public domain of the SODEA/SOGETA[6] parceled out to investors, or acquired on the market[7]. In the Saïss Plain, Fofack (2012) has also found that farmers could sometimes go through either the *caïdat* (Ministry of interior) who can mediate the request through the ABH, or through the sellers of drip irrigation systems, who can take care of the application process and possible arrangements with the Ministry of Agriculture. These parallel lines of authorities undermine, if not nullify, the responsibility of the ABHs for sustainable water use.

In other words, the PMV is not always subsidizing conversion to drip irrigation but is also planning expansion of groundwater-based private irrigation. The expected additional water demand is

[5] Such a level of subsidy has generated a situation where irrigation equipment salesmen and design companies enter directly in contact with farmers or water user associations to propose them turnkey projects in which they take care not only of the implementation of the project, but also of the administrative procedure to receive the subsidies and request drilling authorizations (BRLi and AgroConcept, 2012).

[6] Public bodies in charge of managing land recovered from colons after independence (and not redistributed).

[7] The intricacy of Moroccan land tenure has also often been seen as an obstacle to development (World Bank 2008). In 2005, a new law (so-called 'de la main levée') allowed members of Agrarian reform cooperatives to obtain a private title for their plot of land, and therefore to trade it on the land market (Valette et al. 2013). Collective lands under customary ownership (terres collectives) have also long been coveted by investors to develop new tree plantations, such as in the Haouz or the Souss (BRLi and Agroconcept 2013), and these lands are attributed by and under the control of the Ministry of Interior, which lies outside of the prerogatives of line ministries. They are also facing a process of privatization (with 300,000 ha of collective land about to be registered in the name of right holders)(Belghazi 2016). Other types of traditional collective land tenures (habous, guich) are also under pressure to be privatized (maroc.ma 2015).

estimated at 1 Bm^3, according to the Monitor Group (2008). To which must be added the likely increase in water consumption due to the intensification and expansion associated with drip irrigation. Investments to raise agricultural production, and land and water productivity probably have a positive impacts on wealth generation, incomes and jobs (although this conclusion is subject to debate)[8]; but they run counter to hydrological realities and belie the official window-dressing discourses that underline the integration of sectoral policies and objectives.

4.5 Privatization and PPPs

The financing of both the O&M of existing ORMVAs and the development of new irrigation infrastructure has long been seen as a recurring burden (Belghiti 2004). Morocco has been very receptive to ideas of privatization of services in general and has also largely operated a transfer of technical water expertise from the state to private companies. In the 2000s the World Bank, and later the French Development Agency (AFD), assisted Morocco in carrying out feasibility studies about the autonomy of the branch of ORMVAs responsible for water delivery services, through private or parastatal entities. These studies have not identified a viable economic model for such institutional change, largely because of the impossibility to generate enough profit to attract private companies.

But the idea of private sector involvement in funding and management has been shifted to new projects promoted under the seemingly fashionable label of PPP and targeting high-value agriculture because of its capacity to pay for part of the investment and for high delivery costs. Such an approach was first initiated in the Guerdane area in the Souss region (Houdret 2012; Houdret and Bonnet 2016). A private company built a pipe to transfer water from a dam to a 10,000 ha where groundwater depletion had strongly impacted the profitability of citrus farms and dried up orchards. The investment of €70 million has been shouldered by the state (48%), the company (44%) and the users (8%), pointing to a still considerable level of subsidy. This project *de facto* limited access to water to capital-intensive farmers and was not immune to financial problems (e.g. the drop in the profitability of citrus and the wave of defaulting on water fees in 2015)(Houdret and Bonnet 2016); not to mention than in a closed basin such a transfer also amounts to a spatial reallocation of the resource.

Another project is starting in the Coastal Chaouia region (between Azemmour and Bir Jdid): an area of 3200 ha cultivated by 600 farmers will receive 15 Mm^3/year from the Oum Er-Rbia river and the delivery service has been entrusted to a private company; 90% of the €37 million needed for the infrastructure will come from the state (Albayane 2013). Another project is being completed in the Massa region (south of Agadir), where a desalination plant will be built to irrigate market crops and citrus for export. Yet another project concerns the transfer of 100 Mm^3 of water annually from the Mdez dam on the Sebou River to the Saïss Plain, where the aquifer is being depleted. All these projects still include large outlays of public money for the investments and their profitability, from the perspective of the managing operator, is linked to the possibility to charge water fees that are higher than in ORMVAs and fully cover delivery costs. This clearly targets the production of cash crops by a capital-intensive agriculture favored by the government.

5 Threats and future prospects

5.1 Production vs. environmental conservation: sectoral contradictions

At the beginning of the 2000s, the water strategy stressed "the necessity to integrate the diverse programs and policies on development, water and the environment, and to ensure their consistency"

[8] Discussing the merits of the PMV lies beyond the scope of this chapter. For a critique see Akesbi (2012, 2014), Bentaleb (2015), and Salem and Ait Benhamou (2016).

(ONDH 2004). Later, in 2008, Morocco gave itself an "ambitious and innovative [updated] National Water Strategy (…), with a roadmap for water management and precise quantitative objectives up to 2030", that "has been harmonized and made consistent with that of agriculture documented, in the PMV", according to the CESE (2014).

Behind conventional political window-dressing, it is now becoming increasingly clear that Morocco's adherence, up to these days, to the longer-term strategy of "not one drop lost to the sea" (World Bank 1995) is now proving incompatible with environmental sustainability. As early as 1995, the World Bank (1995) clearly showed little enthusiasm for the irrigation expansion policy of the government, underlining that "The Government's objectives of expanding irrigated areas, in the context of increasingly scarce water supplies, rising costs and less protected output prices, poses a severe challenge for irrigated agriculture". Twenty years later Morocco is still intent to develop 140,000 ha of what it calls a 'catching up' (*rattrapage*) with development plans, slowly taking the last excess river basin – the Sébou – towards full commitment of its water resources.

But beyond the water sector itself, the worsening status of groundwater resources has much to do with the contradictory and antagonistic policies of the Ministry of Agriculture. As demonstrated earlier, support to agricultural intensification through drip irrigation, and to expansion by subsidizing investors is detrimental to the water status of the country. More generally, it is the environment which is being impacted by the stressed water regime (seawater intrusion, degraded wetlands, polluted rivers, dried-up springs, etc.) (MEMEE 2010; Akesbi 2014). The culture of the ABHs, the decentralized 'regulators' under the Ministry of Water, is inherited from the former Regional Hydraulic Directorates and is only slowly being directed towards environmental sustainability. The limited power entrusted to this Ministry is indicative of the current political priorities of the Moroccan state.

Agricultural policies are also coupled with energy policies but the PMV has been largely elaborated without consideration of its impact on the energy sector, despite the impact of the conversion to drip irrigation on the country's €10 billion energy bill (96% of Morocco's energy is imported), 13% of which on account of agriculture (Doukkali and Lejars 2015). In 2011, total subsidies involved in energy consumption by agriculture amounted to €0.75 billion (ibid.).

The CESE (2014) recently issued a disquieting report emphasizing the absence of an operational regulatory body in the water sector (the inter-ministerial Committee being non-operational for years), failures to properly implement the 1995 Water Law (e.g. with regard to the polluter-pay principle, safeguard and prohibition zones on overexploited aquifers, sanctioning, etc), insufficient coordination between department concerned with water, ABHs lacking means, autonomy and independence, and the *Conseil Supérieur de l'Eau et du Climat* (CSEC) having unclear roles and prerogatives.

5.2 Regional water deficits and what they mean for irrigation; national planning

Irrigated agriculture, although limited in terms of area when compared with rainfed agriculture, is a major contributor to the agricultural GDP as well as national exports. Its share of total water use is around 84%. In a context where most river basins (except the Loukkos and part of the Sébou) are overexploited, this suffices to understand how the future of irrigation is tightly associated with the future of water resource development and status.

It is becoming increasingly clear that much of the participatory gloss put on the National Water Strategy, the decentralization of management at the level of river basins, the elaboration of the PDAIREs, or the expected aquifer contracts do not fundamentally alter a policy that is still largely based on state-planned supply management (subsidies to well drilling by the PMV, remaining marginal dam sites to be developed, north-south transfer, desalination, etc). The reality is a desiccation of the country gradually expanding northward and 'downward' (with at least 1 Bm^3 of

groundwater depletion each year), under continued and unchecked water resources development by both the government and individual farmers or investors.

In Morocco, the process of basin closure started in the Souss-Massa in the 80s, moved North to the Tensift and the Oum er-Rbia, and is underway in the Sebou[9], where the remaining surplus water will soon be committed (100,000 ha expansion in the Gharb, irrigation development in the middle-Sébou, transfers to the Saïss Plain, increasing urban needs in Fès and Meknes, water transfers to Casablanca and further south, etc). Although exhibiting a deficit of 840 Mm^3/year (ABHOER 2012), the Oum er-Rbia basin is strikingly *still* witnessing an expansion of irrigation, like in Khenifra, or in the coastal Chaouia area…

As alluded to earlier, all major aquifers are now overexploited, with a drop in water levels, a depletion of at least 1 Bm^3/y, and negative impacts on springs and river baseflow (Maroc.ma 2014). A situation that prompts GIZ (2014) to stress that with no action "the exhaustion of the aquifer in the short term is inevitable, with severe socio-economic as well as ecological consequences". Yet, as one magazine observes, "The drop in the cost of well drilling, pumping and irrigation equipment, as well as subsidies allocated by the state have encouraged the farmers to invest in wells", and with the lack of rain in 2015-2016 "professionals of the well drilling and irrigation equipment sectors see with satisfaction their activities on the rise" (Finances Hebdo 2016). Thirty years ago (in 1974) the masterplan for the Souss basin stated specifically that should the private sector continue to disregard planting or pumping bans, it should in the future fully bear the most disastrous consequences (ABHSM 2010).

Regulation of demand in order to keep it in line with available resources is the responsibility of the ABHs but these lack funds, are understaffed and with budget deficits. They have been involved in data collection, contracting out technical studies, licensing of well drilling, or yearly water allocation, but in their planning tasks and have had to compromise with the ORMVAs (representing agriculture), the Ministry of Interior and private interests (Tanouti 2017). The PMV makes light of environmental limitations and even provides a loophole for farmers to drill subsidized wells in overexploited aquifers, in contradiction with attempts by the ABHs to regulate (over)exploitation.

The overextension of irrigated farming makes it very vulnerable to climatic vagaries. In case of prolonged drought, its supply will have to be dramatically curtailed. Impacts will be all the more serious because the percentage of tree crops is growing and this may result in the loss of sunk capital. Whether because of climate irregularity or exhaustion of groundwater resources, irrigated agriculture, currently merely seen as an engine of growth, is poised to be impacted by failing water supply.

The overall bleak water situation of Morocco does not mean that no agricultural expansion or intensification is possible. However, identifying what can be done and where without further impairing the water balance requires the development of a more elaborate knowledge of hydrology, with more attention to return flows, changes in stocks, and surface/groundwater interactions.

5.3 Climate change

Studies carried out in the late 2000s to update River basin masterplans found a decrease of "regularized volumes" by around 30%, compared with earlier masterplans [done around 30 years earlier]. This difference is even sharper at the level of river basins such as Bouregreg, Oum Er Rbiâ and Sébou (46%, 45% et 38% respectively) (El Gueddari and Arrifi 2009). The annual potential of renewable water resources, hitherto estimated at 30 Bm^3, is now considered to be 22 Bm^3 (MAPM 2007b).

[9] The PDAIRE, under optimistic hypotheses and disregarding climate change, foresees an average discharge to the sea in 2030 of 500 Mm^3, roughly 10% of average available resources in the basin. While the upper Sebou basin is increasingly overcommitted, northern catchments in the Rif region contribute a lot of runoff (largely stored in the Wahda dam) but these resources cannot be transferred at acceptable costs.

Even though a lot of uncertainty remains, climate change predictions all point to a continued trend in the occurrence of extreme events and in rainfall reduction, and "the country's water resources, both superficial and groundwater, are expected to further slump by around 15 to 20 percent by 2030" (MAPM 2007b). Aoubouazza et al. (2013) forecast a drop in water availability between 14% and 23% by 2050, and Driouech, (2010) a decline in rainfall by 20% and a rise in temperature between 2 and 6°C by the end of the century.

Yet, surprisingly, PDAIREs do not consider these expected reductions and plan water resources on the basis of current availability. The PDAIRE for the Tensift bears no mention of climate change; add-on studies have been conducted after the publication of the PDAIREs to study the impact of climate change in some basins, like the Oum Er Rbia where the supply-demand deficit estimated by the PDAIRE at around 560 Mm^3 for 2030, was found to be rather around 1500 Mm^3, with the observed climate trends and forecasts available to date (Hydraumet 2013)[10]!

In other words, not only is Morocco currently still increasing resource mobilization and stretching out its irrigation area, but its planning -against all evidence- is disregarding the coming increase in temperature and evapotranspiration, and decrease in rainfall and runoff. Irrigated agriculture stands out to be the most impacted.

5.4 What future for irrigated agriculture?

While the future of irrigated agriculture is primarily threatened by the status of water resources, it also has to face several other challenges. The financing of reconversion to drip and of expansion heavily draws on financial resources. €3.6 billion are slated for the PNEEI and Doukkali and Lejars (2015) estimate subsidies at €11,000 per ha, on top of the subsidies allocated to other agricultural investments. Mobilizing ever marginal and costly water, transferring water from the North to the South, desalination, etc. are supply-augmentation policies largely made inescapable by the continued expansion of irrigation. They form a large part of the National Water Plan, which will require a total investment of $27 billion (Telquel.ma 2014).

Irrigated agriculture is also potentially threatened by a risk of deepening socio-economic differentiation which could result from policies such as the PMV, or the PPP projects, which systematically favor a model of capital intensive agriculture linked to export markets. The PMV is seen by some experts as perpetuating the productivist and technicist policy models that Morocco has implemented, from colonial time throughout to current days, to tackle a situation that is known as the 'duality of agriculture' (Akesbi 2012, 2014; Ihazrir 2009). While the first pillar of the PMV is devoted to boosting 'modern' agriculture, the second 'pillar' is supposed to help small landholders transition towards a 'modern' agriculture (Faysse 2015), grossly overlooking the social reality of the countryside according to Akesbi (2014).

Another process of social differentiation is being observed in areas which critically depend on groundwater. In the Tadla scheme (Kuper et al. 2012), the Souss basin (BRLi and Agroconcept 2013) or the Saïss Plain (Ameur et al. 2017), the necessity to access groundwater at ever increasing depth and costs clearly favors investors growing cash crops to the detriment of small holders without the capacity to deepen their wells or shoulder these costs. More generally interventions on the water cycle, whether through technological change such as drip irrigation or wastewater treatment, like in Marrakech, often somewhat invisibly redistribute access to water, with an impact on weaker constitutions (Molle 2012).

Last, the future of irrigated agriculture in its different forms is linked to the evolution of factor prices (e.g. the cost of energy or labor) as well as market conditions. The competitiveness of Morocco on

[10] "The water supply and demand balance for 2030 (the current PDAIRE) is optimistic and does not sufficiently integrate climate risk and its possible effect on the potential water of the area to this date: the supply-demand deficit estimated around 560 Mm^3 for 2030 should be rather around 1500 Mm^3, with the observed climate hydro trend and forecasts available already today" (Hydraumet 2013).

international markets is vulnerable to competition by other countries in the Mediterranean and elsewhere, to health or environmental standards, and to unpredictable changes in market prices (Akesbi 2011, 2012).

For the past 15 years, several factors concomitantly contributed to an increase in agricultural production in Morocco: i) the development of intensive groundwater-based irrigation practices in areas previously cropped with rainfed crops or used as pasture; ii) the development of drip irrigation which led to sizable increases in yields, especially for vegetable production; 3) the many incentives for agricultural investments extended by the Green Morocco Plan. However, there has not been a parallel increase in the export of agricultural products. As a consequence, there is an increased competition on domestic markets, especially in the fruit and vegetable sector. For instance, in the Middle Atlas mountains, many farmers have since around 2006 started to invest in intensive apple and plump trees, using boreholes and drip irrigation systems, on land previously devoted to pastures. Sellika and Faysse (2015) and Sellika et al. (2015) showed that the most probable scenario in the 10 coming years (and already apparent in 2017) is a strong decrease in the benefits of apple and plump farmers, a scenario that might affect fruit and vegetable growers using groundwater in many regions of the country.

6 Conclusions

As mentioned in the introduction, Morocco can boast substantial achievements in the water sector and these achievements are well underlined in the literature. The CESE (2014) stresses that Morocco is considered as a "regional and continental model in terms of water management", with an "institutional governance model" and legislative framework considered as "exemplary", and a national water strategy that is "coherent and ambitious". According to Doukkali (2005), "from a historical perspective, the institutional reforms undertaken in Morocco, especially since the new law of 1995, are truly remarkable". Building on a strong historical basis of communal irrigation systems and hydraulic know-how, the state investments in dams and large-scale public irrigation have tripled the irrigated area of the country, before individual farmers and investors drilled wells to develop groundwater-based irrigation, expanding Morocco's aggregate irrigated area to around 1.5 million ha.

Morocco's success with supply management has not been paralleled with corresponding achievements in terms of demand management, and Morocco's adherence, up to these days, to the longer-term strategy of full utilization of its resources (World Bank 1995) is now proving incompatible with environmental sustainability and hydrologic variability. While threats have been periodically well identified they have often resulted in *ad hoc* declarative postures translated into strategies and even laws. But the gap between policy intentions and reality on the ground is now exposing a lack of political will to enforce regulations, in general, and control the expansion of irrigated agriculture, in particular. The overbuilding of public irrigation schemes (whose needs are covered only at 60% on average, and much less in southern basins) has already put most other river basins 'in the red' (Bouregreg, Oum er-Rbia, Tensift, Souss-Massa, Tafilalet), and groundwater-based agriculture has compounded the situation and provoked an annual deficit of 1 Bm^3 (and probably much more than that in reality).

Yet expansion of irrigation is still being promoted by the PMV in the name of modernization, food security, poverty alleviation and other objectives. Morocco tends to be caught up in the ubiquitous (global) incantation that we need "to do more (irrigation) with less (water) in a sustainable way (no overexploitation)", wishfully assuming that the circle can be squared (Molle and Tanouti 2017). Expansion is expected to be compensated by an improvement in the performance of irrigated agriculture, including water savings, intensification and higher water economic productivity. This makes light or even completely ignores that, in most cases, expected savings at the scheme or plot

levels are illusory (because 'losses' largely return to aquifers that are already overexploited, with notable exceptions such as the Doukkala where they go to sinks, like saline aquifers).

Policies enlisted to solve this contradiction are proving ineffective or even counterproductive. The technical fix of drip irrigation comes with enhanced intensification and diversification to cash crops that both tend to result in higher depletion of water. Irrigation modernization also has a bearing on energy use (Raïs et al. 2016) and recent policies aimed at reducing the use of subsidized butane through the promotion of solar energy[11] are extremely worrying in terms of groundwater use. Agricultural water pricing has been proved to be important for cost recovery but ineffective for saving water (especially for groundwater use where wells are not metered in general). Institutional changes, such as the establishment of WUAs or aquifer contracts have not delivered on their promises. The proposed toolbox and the language of alleged 'risk mitigation' measures are distracting us away from the evidence that the country is squeezing itself dry by increasing water resources development and depletion; even more so because government's current subsidies are achieving just the opposite. Such dynamics belie the official discourse that underlines the integration of sectoral policies and objectives.

The development of Moroccan agriculture is however a key national objective. Irrespective of whether current public investments are cost-effective or not, the conversion to drip irrigation has likely benefits in terms of income, land and water productivity. These benefits, however, are largely limited to those who are able to access groundwater individually. Large-scale scheme are being gradually upgraded to provide pressurized water (but this has yet to be tested on the mid-term), while small schemes have problems of land tenure and fragmentation and would require heavy investments. These benefits may even warrant some moderate increase in water consumption, but 1) they should not be drummed up as a solution to water scarcity; 2) they should be geographically concentrated and allowed only in areas deemed compatible with the current availability of water resources. Morocco's knowledge of its water resource, despite a respectable data collection network, is now clearly insufficient to address the challenges of managing closed basins and overexploited aquifers.

Irrigated agriculture is witnessing a number of challenges that will become more acute in coming years. From a social point of view, various dynamics of social differentiations are at work (fostered by export markets standards, price vagaries, growing water abstraction costs, etc), while climate change will both substantially reduce available supply and include more extreme events which will be increasingly hard to weather in basins where resources are already overexploited. Morocco's is currently reaping short-term political and economic benefits at a high a financial cost (PMV), but at the cost of a growing long-term vulnerability to social and climatic upheavals which have also, history has it, unsettled its political stability several times in the past.

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