Chapter 10

Irrigation Policies in the Mediterranean: Trends and Challenges

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Abstract

Irrigation is a central feature of agriculture in Mediterranean countries. During the 20th century, and more specifically after World War II, most states have invested massively in large-scale dams, interbasin transfers, and public irrigation schemes. More recently, farmers have capitalized on increasingly cheap pumping devices to tap groundwater, whether in conjunction with surface water or not, and the introduction of pressurized networks has come to constitute a major technological change in the region. This chapter first reviews the changing relationships between irrigation and the wider water sector as scarcity builds up, and ponders on the respective prospects for both supply- and demand-management options. It then takes stocks on recent technical and institutional changes in the irrigation sector before turning to the importance of economic dimensions and context. Finally irrigation is analyzed in terms of policy and political process, and of its relationship with other sectors, while the final section explores the challenges posed by water overexploitation, environmental degradation and climate change.

Keywords: Irrigation policy, water management, water governance, participatory management, groundwater water-energy nexus, modernization, Mediterranean basin

1 Introduction

Irrigation is a central feature of agriculture in Mediterranean countries.[1] Dry environments or relatively low precipitations that largely fall outside of the summer periods have long pushed communities to develop small-scale infrastructures to capture, store and divert water to their fields. During the 20th century, and more specifically after World War II, most states have invested massively in large-scale dams, interbasin transfers, and public irrigation schemes. More recently, farmers have capitalized on increasingly cheap pumping devices to tap groundwater, whether in conjunction with surface water or not, and the introduction of pressurized networks has come to constitute a major technological change in the region (whether dominated by sprinkler like in France or northern Italy, or drip, like Israel and Spain).

The expansion of irrigation to an extent that hovers around 23 million ha in Mediterranean countries has gradually faced a host of financial, economic, technical, environmental and institutional problems. The large-scale manipulation of water has altered the hydrologic cycle, affecting springs, wetlands, and flows between streams and aquifers, but also generated problems of contamination and soil salinisation. Infrastructure have proved to be costly to maintain and upgrade and shifting these costs onto users to be problematic. Relationships between the state and irrigators have been largely imbalanced (although Spain and a few places offer some exceptions) and irrigation has become but one user within a larger water management framework that must accommodate

[1] Unless otherwise indicated, the information synthesized in this chapter is described in more detail in respective country chapters, where the reader will also find sources and references.

dwindling and increasingly variable resources, increases in temperature and evapotranspiration, sectoral competition with a priority to urban and tourist uses, and the recognition of water as an environmental resource. Last, irrigated agricultural production finds itself reshaped by the globalization and vertical integration of food production.

In this concluding chapter, we build on the preceding country-level analyses to offer a general overview of the trends and challenges faced by irrigated agriculture in the Mediterranean.

2 Irrigation as the main water user

2.1 Irrigation as a wasteful practice?

Worldwide, irrigation is responsible for 70% of total water withdrawals (Molden et al. 2011) and around 92% of water consumption (Allan et al. 2015). In the Mediterranean, as seen in the introduction to this volume, these percentages are even higher due to the semi-arid to arid climate that prevails in a large part of the region. Since irrigation and environmental needs receive in general a lower priority than domestic and industrial uses, they generally bear the brunt of the hydrological variability and of water shortages. But irrigation also comes under criticism for being a wasteful practice. "At present, it is fairly common to find that more than half the amount of water withdrawn from the resource does not even reach the fields being irrigated", note Hamdy and Lacirignola (1997) in a typical statement put forth to suggest that here lies the key to solving water scarcity if –only– irrigation were able to improve its overall efficiency.

The pervasiveness of the flawed extrapolation of plot-level efficiencies to wider scales by cross-multiplication is puzzling. The fallacy has been sustained by international organizations like UNEP's Blue Plan, which derived from it unrealistic water-saving targets at the country level (Blinda 2009). In the Nile Delta, a place ironically used in the 1990s to develop the understanding that systems with substantial reuse of water need careful examination (Seckler 1996), the Ministry of Agriculture entertained the idea that savings could reach 12.4 Bm^3 that could be used for land expansion (a value that is coincidentally roughly the amount of water pumped out to the sea). In Morocco, official documents and statements refer to water saving targets associated with drip irrigation anywhere between 0.85 to 3 Bm^3, without substantiation. Similar expectations have been found in Spain and in Turkey, in the Konya basin, for example. Such claims are made in river basins that are more often than not 'closed', that is, where outflows are roughly limited to uncontrollable sporadic floods. While some northern Mediterranean rivers (e.g. Ebro, Rhone, Po, Seyan), or the Moulouya in northern Morocco still carry substantial volumes of water to the sea, most other rivers don't, and are closing or closed (e.g. Oum Er-Rbia, Tensift and Souss-Massa in Morocco, Júcar and Segura in Spain, Chelif in Algeria, Nile, Orontes and Jordan rivers, etc).

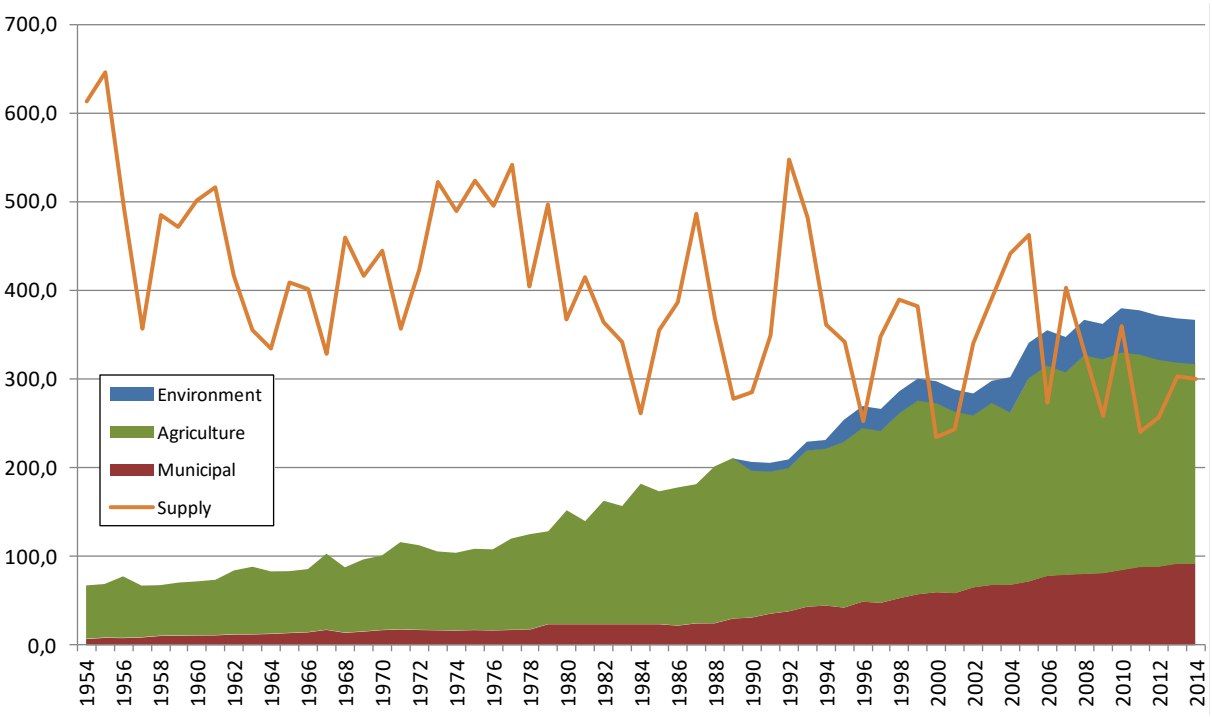
Basin closure process, whereby the demand induced by water resource development invariably comes to exceed the resource available, is a generic process observed worldwide and well described in the literature[2]. In countries where viable agriculture is highly dependent on irrigation, farmers (and the state) have gradually tapped whatever surface or groundwater can be abstracted and this includes –crucially– return flows from existing irrigation use, whenever this return flow is not degraded by its flowing to a sink like a saline aquifer. As basins close they are increasingly akin to a zero-sum game where evapotranspiration cannot be increased (either by intensification or expansion) without reducing it somewhere else in the same proportion (unless this increase is based on additional groundwater depletion). This hydrologic reality is often either conveniently glossed over and/or non-understood by decision-makers and managers in the region.

[2] See Keller et al. (1998), Molden et al. (2001), Molle et al. (2010).

2.2 Irrigation and the 'double squeeze'

Irrigated areas have soared during the second half of the 20th century globally and in the Mediterranean. This has been the result of large public investments in collective schemes and, more recently, of the boom in groundwater-based irrigation (more on this later). As a result, irrigation water demand has ballooned and in many places outpaced the amount of water mobilized and controlled. At the same time municipal and industrial water demands (the latter to a lower extent because of improvements in technology) have grown steadily. Since this demand is in all countries considered to be a priority (whether by law or de facto), the hydrologic variability is fully passed on to the environmental and agricultural demand. In EU, the former has now been recognized and prioritized over the latter, but the opposite is true in most other countries. The competition from cities is illustrated by Tunisia, Southern Italy or Spain, where irrigation allotments often had to be capped or reduced. The vulnerability of this huge demand is now compounded by both a higher climatic variability and a downward trend in terms of annual water supply. Consequently irrigation water demand is now facing a 'double squeeze' that reflects both declining supply and the growth of other priority uses, resulting in a higher frequency of years where demand from agriculture and the environment cannot be met (Figure 1). The shortfall either results in curtailing irrigated agriculture and/or in depleting groundwater stocks.

Figure 1. Irrigated agriculture and the 'double squeeze' (hypothetical case, no unit)



The environmental demand shown on the figure reflects the growing awareness, and sometimes legal recognition, of a 'demand' that has long been ignored or overlooked. In France or in Spain, for example, because of limited knowledge about natural resources systems, the lack of environmental concern in the past, and the importance of water for the local economy and politics, abstraction authorizations delivered frequently exceeded the available resource.

A mitigating factor of the 'double squeeze' is the reduction of irrigated areas due to urbanization. In Tunisia unplanned urban expansion, combined with the development of industrial zones, is encroaching on public irrigated areas (e.g. *Grand Tunis*) despite regulations to protect this type of land (of which 28% is affected by this phenomenon). In

Egypt, the yearly loss of arable land to urbanization was estimated at 10,000 ha but this rate has rocketed up after the 2011 revolution. In Marrakech, or in the *Conca d'Oro* of Palermo where a magnificent citrus garden was destroyed between 1950 and 1980, villas and tourist facilities are slowly replacing agriculture. In Spain, citizens are reacting against this urban sprawl processes and the defenders of the Granada, Zaragoza, Murcia and Valencia historical gardens have joined in an umbrella organization (*Intervegas*) to demand legal measures for land protection and agricultural conservation, particularly gravity irrigation practices[3]. Other conservation and restoration actions have been developed throughout Europe (Leibundgut and Kohn 2014).

Another mitigating factor is the fact that a part of the water going to cities is not consumed and returns to the river/aquifer system. By reusing this water (whether treated or not) agriculture can recover a large part of the water that had been diverted away to cities. Nowhere is this clearer than in Israel where agriculture is largely decoupled from (fresh)water, as treated wastewater is now its main resource. This decoupled model is also being put in practice in some tourist areas of Spain, where WUAs are seasonally exchanging water rights with the urban sector, using wastewater for irrigation against a financial compensation.

2.3 The groundwater revolution

Groundwater has for centuries been tapped through *qanats* (also called *khettaras* in Morocco, or *foggara* in Algeria) and wells, but technology constrained the amount of water that could be abstracted. In the past thirty years or so, cheaper pumping devices have fuelled a boom in groundwater use that occurred in three different types of situations. First, wells have gradually appeared in most large-scale public irrigation schemes to make for the growing shortfall of water. The intensity of conjunctive use is a good indicator of the (in)adequacy of irrigation water supply. In schemes like Tadla in Morocco, individual wells have been massively dug since the 1980s (see Hammani and Kuper 2008), when the Oum Er-Rbia basin started to be overexploited. A similar situation was observed in the Gharb scheme in Syria's Orontes Valley, in Central Anatolia, and Spanish or Italian public schemes. Even in the *Consorzio di Bonifica di Piacenza* in Emilia, in the Po Valley, 40% of irrigation water is sourced from aquifers. In the southern Capitanata Scheme, this percentage varies between 50% and up to 100%, depending on the year and the water situation. In other places this phenomenon is more recent, like for example in the Nile Delta where intensive well drilling has been observed in the past 10 to 15 years (El-Agha et al. 2016). In some places (Egypt or Turkey) the state has even drilled its own wells to supplement its public irrigation canals. Second, tubewells have provided supplemental irrigation water to crops in appeared in areas with rainfed agriculture, typically in Spain, France or Turkey, but also in Morocco or Syria, providing smallholders with an opportunity to intensify (Allan 2007). Last, tubewells have allowed irrigated agriculture to expand into arid or desert areas, like in Morocco, Algeria or Egypt, in particular around oases that had long enjoyed artesian wells and springs.

In all Mediterranean countries, states have attempted to establish registers, permits, or rights for the use of groundwater. But whether in Italy, Spain, or Southern countries this proved insufficient to prevent illegal and/or excessive water abstraction. Typical state control instruments such as permits, well spacing, depth limits, local bans, meters, pricing, have been as little successful as elsewhere (see Molle and Closas 2017) and illegal wells have flourished throughout the region. EU countries have started to define quotas at the aquifer level and to involve mandatory water users' associations (Spain) or OUGC (France) in collective management through the definition of quantitative thresholds and measures to be taken depending on the hydrologic situation. But in Spain only 392 of the 730 groundwater bodies are now in good state and in the Mediterranean basin altogether most of the

[3] In the case of the Valencia 'market garden' (*horta*), whose degradation was defined by Courtot (1994) as foreshadowing "the end of a myth", a recent regional law (2018), promoted by a popular mobilization, has protected all the historical lands of the "Horta" from urban development, and an Agricultural Development Plan is to be launched before the end of 2018 to strengthen agricultural activities.

overexploited basins, with typical drops in the water table of 1 m/y, have little hope to see their level stabilized, let alone to recover. Impacts are particularly severe in coastal areas, where sea-level rise and aquifer drawdown combine to promote salinity intrusion. This can lead to the destruction of irrigated agriculture, as observed in Italy, Morocco or Tunisia. Other impacts observed concern wetlands (e.g. the Tablas de Daimiel, Spain; Marrakech palm grove; Azraq Oasis in Jordan).

Regulation is made extremely difficult by a high number of disperse and often unknown wells, lack of data, and sometimes legal or religious considerations. But the reasons for a general laissez-faire attitude are largely political (Kuper et al. 2016; Molle et al. 2017a): groundwater is often the resource that small individual farmers are able to tap locally to make a livelihood, or to intensify or safeguard their crops. Tough action by the state is poised to generate social unrest and strong reactions. Local tensions and conflicts around groundwater in Morocco (Souss Massa) or Tunisia (Bsissi), or environmental degradation resulting from overdraft in France (Beauce) and Spain (La Mancha), show how states can be forced into action to initiate deliberative processes with users. In some other countries (e.g. Egypt, Algeria, Morocco), groundwater use is also associated with personal or corporate interests close to decision-makers that also work against regulation.

The region is also home to a few interesting experiences with collective groundwater-based irrigation schemes. Tunisia (GDAs) and Morocco (in the Souss basin), but also Spain under Franco (Closas 2018), have built groundwater-based public irrigation networks. Pump stations on a single well but used and managed by a collective are frequent in Turkey, where Groundwater Irrigation Cooperatives have been established since the late 1960s, and Tunisia, with some cases also in Egypt. This has not been seen as a viable option by other governments, although farmers themselves have taken the initiatives to invest collectively in wells for their irrigation, notably in Spain and the Nile Delta.

2.4 Bringing more water (and sustaining unsustainablity)

When irrigation activities are threatened by a lack of water, whether because supply is reduced by drought events or competition from other sectors, or demand increased by state-driven basin 'overbuiding' (Molle 2008) and individual initiatives, governments usually look for supply-augmentation options. Bringing more water in, at public expense, is always politically easier than leaving angry farmers dealing with shortages, or imposing on them harsh measures to curtail their use.

Inter-basin water transfers for irrigation have been popular in Spain (0.35 Bm^3 from Tajo to Segura, but frustrated in the case of the Ebro transfer), in Greece, in France (SCP delivering water to the coast), in Italy (0.8 Bm^3 transferred across Southern Apennines mountains), in Tunisia (0.4 Bm^3 from northern mountain ranges to the south), Algeria (numerous projects) and in Morocco, which is planning the transfer of 0.8 Bm^3 from north to south.

Such transfers are often presented as a way of 'redressing nature imbalances', as a question of hydro-solidarity (Spain, Morocco or Tunisia), but they are costly (tunneling and pumping are generally needed) and increasingly resented or combated by donor-basin regions (e.g. in Spain). The Tajo-Segura Water Transfer in Spain and the Rocade Canal, in Morocco, illustrate how such projects are designed based on high volume targets but only end up delivering a smaller portion of water (35% for the former, 60% for the latter), thus generating water scarcity, shifts towards groundwater, or even a demand for additional water transfer infrastructure…

Wastewater has also been identified as a complementary "resource" to be treated and reused in agriculture (Qadir et al. 2007). United Nations' 2017 report entitled "Wastewater…The Untapped Resource" has recently put the issue center stage. Tunisia has been a frontrunner, with the reuse of Tunis water initiated in the 1960s. Turkey's area irrigated with wastewater was believed to be about 200,000 ha in 2004. Israel turned to wastewater reuse in the 1990s and as of today 86% of the treated wastewater is reused, mostly in agriculture. Spain came to it in the 2000s (with around 450

Mm^3/y of water, while further expansion plans have been delayed by financial difficulties). Some countries like France, Morocco, Algeria or Egypt have not yet developed ambitious strategies to tap this resource. In the latter three countries, wastewater is actually already used in many places, even though it is not treated.

Desalination is also a way to augment supply and plants are gradually appearing around the Mediterranean, notably in Israel, Algeria and Spain. But high production costs confine this resource to domestic supply. Exceptions include areas with high-value horticulture crops for export around Murcia/Almeria (Spain), and the plant under construction in the Massa basin (southern Morocco) through a PPP arrangement where water will be sold to investors and make for dropping aquifers.

Last, supply augmentation options also include on-farm storage or small communal reservoirs (like in the "1000 days 1000 reservoirs" program in Turkey) (see Le visage et al. 2018). In France on-farm storage is the main response to irrigation needs in summer, after pumping from small streams came under criticism for drying up rivers.

Responding to shortages by increasing supply without regulating uses has the well known effect of encouraging users to expand, in a vicious circle poised to generate more shortages.

2.5 Water scarcity and demand management

In the late 1990s early 2000s, the disqualification of supply-augmentation policies generated an emphasis on demand management as an alternative (Chohin-Kuper et al. 2014). Its insufficient potential to redress severe imbalances has transformed this emphasis into a call for not antagonizing both approaches and carrying them out in parallel; when supply management does not come back strategically couched in discourses about green development, sustainability, and the like (Crow-Miller et al. 2017).

Demand management combines interventions to reduce 'losses' in urban or irrigation distribution networks, measures to reduce demand by users (retrofitted appliances, drip irrigation, water pricing, awareness raising campaigns, etc) and to reallocate water. In the Mediterranean the UNEP Blue Plan and GWP have been spearheading the policy emphasis on demand development (Blinda 2009, GWP 2012). Although these measures are in general desirable, they have been found wanting in many situations and their potential now appears as being much more limited than often enthusiastically believed, especially in the field of irrigation.

There are two major reasons for this state of affair: first, reducing demand often implies a form of constraint and likely discontent, which makes this policy politically unattractive; second demand policies are implemented in water scarce basins where little water is 'lost'. In what follows we will in particular briefly examine the record of interventions aimed at raising efficiency, irrigation water pricing, and participatory managerial approaches.

3 Irrigation management and technical change

3.1 Irrigation's varying context and purposes

During the past decades, agriculture has lost economic and political weight in Mediterranean countries, as its contribution to national GDPs and, to a lesser extent, it importance in the provision of jobs have steadily declined (Figures 2 and 3).

Figure 2. Agriculture, value added (% of GDP) in selected Mediterranean countries. Source: World Bank (2018)

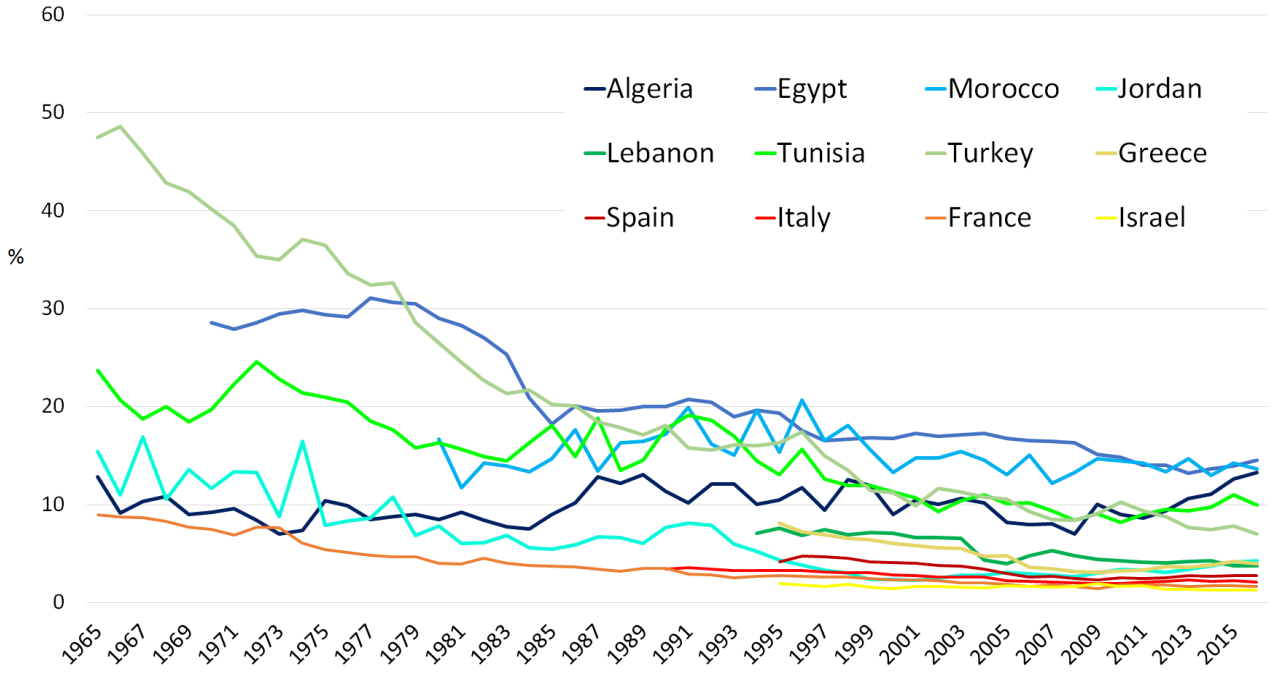
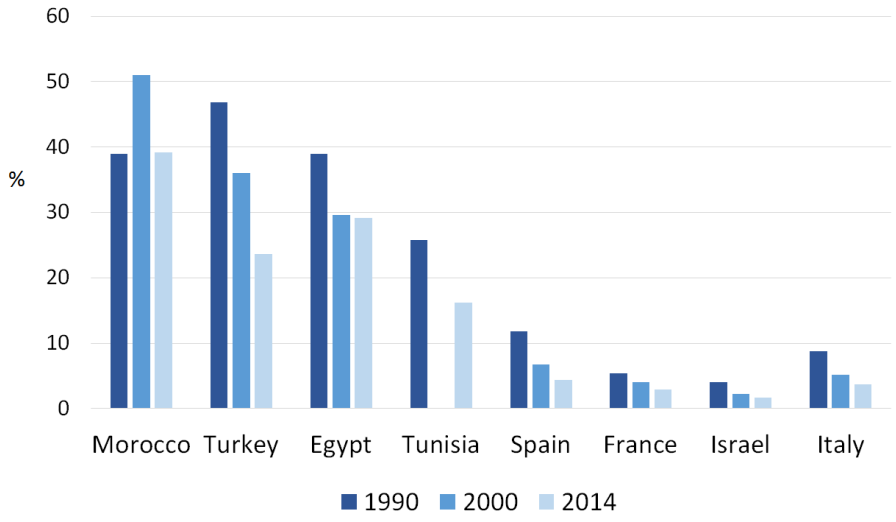


Figure 3. Agrarian employment in selected Mediterranean countries (% of the total workforce). Source: FAO



Markets liberalization and global competition, the development of food corporations, climate vagaries, labor-saving technologies, and farmers' ageing have slimmed down the whole sector agricultural in the region. In this context of decline, irrigation has become the most common strategy to offset climate uncertainty and risk, secure or increase farms' productivity and competitiveness, and in some cases, the only opportunity for many smallholdings to maintain their activity. In Turkey, the benefit of irrigation in terms of yield increase is 273% for cotton, 147% for fruit trees and 155% for citrus, while the largest increase (a six-fold increase in yield) is achieved for maize (DSI, 2017). In Spain, the mean net margin per hectare in irrigation is 4,4 higher than in rain-fed areas (Gómez-Limón 2014). Similar rates have been observed in the rest of Mediterranean countries.

Irrigation is paramount for both agribusiness and family farming, and plays a major role in retaining population in the rural areas of European shores and in combating rural poverty in other countries. The socio-economic importance of irrigation is still used as an argument to justify expansion policies and to forge a consensus between the farming sector and policy-makers. In Turkey, an alliance of stakeholders -the state bureaucracies, WUAs, chambers of agriculture, engineers and other concerned NGOs- has sustained the recent expansion of the irrigated lands, and firmly supports the target of 8.5 million ha to be developed. Egypt announced plans to expand agriculture in the desert on 400,000 ha although past experience with such plan is not encouraging. In Tunisia, Morocco and Spain lands irrigated with groundwater have been expanding during the last two decades, with the support (or passivity) of the administration. In Spain irrigation areas have expanded from 3.3 Mha to 3.7 Mha between 2000 and 2017, and the administration and the FENACORE[4] defend this growth because of the alleged decrease in the water used for irrigation during the same period (from 17.6 to 14.6 Bm^3, according to the Ministry of Agriculture), attributed to the generalization of pressurized networks and other water-saving technologies.

Nevertheless, France and Italy, after several decades of growth, followed a different trend during the 21st century. In France, the area equipped for irrigation decreased by 12% between the two last agricultural census (2002 and 2012), as the socio-political support for this kind of investment weakened. In Italy irrigated lands have been decreasing since 2000, but non-irrigated agricultural areas decreased even more (also in France and Spain), suggesting that irrigation contributes to sustaining agriculture, slowing down the general decline of the sector.

3.2 Large-scale public irrigation under question

Iconic large-scale public irrigation schemes have been developed by the states, mostly during the 1960s up to the 1980s. This has notably been the case in Spain during Franco's regime, in central and southern Italy (Reclamation and Irrigation Consortia), Morocco (where King Hassan II's 'hydraulic policy' sought to develop one million hectares of irrigated land), in Algeria during the Socialist period (in coastal plains and in the Sahara), in northern Tunisia, Syria (Orontes river basin), not to mention the continued expansion of the Nile delta/valley system.

This 'hydraulic mission' has been undertaken by, but also strengthened, powerful bureaucracies such as the Ministry of Water Resources and Irrigation in Egypt, the Ministry of Agriculture in Tunisia, the National Institute of Colonization (NIC) and the "*Dirección General del Agua*" in Spain (created during Franco's regime), Mekorot in Israel (funded in 1937), or the DSI in Turkey. The DSI was modeled after and supported by the US bureau of Reclamation, and its first director (S. Demirel) even became president of the country. It is the only administration in the region to still have a substantial irrigation expansion and construction program.

The hydraulic mission time correspond to times when there was a considerable demand for rural development and large-scale public projects (Molle et al. 2009) and 'development states' could count on the responsiveness of development banks and transnational consulting companies. This mission conducted in the name of national sovereignty, food self-sufficiency or poverty alleviation gave rise to dams, large-scale irrigation schemes and other hydraulic infrastructures. They also served the objective of nation-building and of consolidating symbolic and political capital for ruling regimes (Franco in Spain, Asad in Syria, Nasser in Egypt, Hassan II in Morocco, etc.)(ibid.).

Because of management problems, low technical efficiency, contested economic profitability, recurring financial burden in the form of periodic rehabilitation, environmental impacts (soil salinisation, waterlogging, dry springs, rivers and lakes, etc), they have therefore frequently been the object of successive waves of reforms addressing technical (modernization), financial (water pricing),

[4] Federación Nacional de Comunidades de Regantes de España (Spanish National Federation of Water User Associations)

or institutional (participatory management; privatization) aspects. These reforms are discussed in the following sections.

Though these public investments incurred substantial outlays, it was found that many are surprisingly underutilized, with low cropping intensities[5]. In Tunisia, the overall cropping intensity in irrigated areas is estimated at 60 % of the potential due to several constraints (water shortages, soil salinisation resulting from a lack of drainage facilities, preference for using groundwater, but also reluctance by some farmers to engage in capital-intensive agriculture when input and output markets are too uncertain). In Algeria, although the equipped area reached 223,377 ha in 2012, the area effectively irrigated was as lows as 68,690 ha, that is, 31%... In Turkey, a considerable portion of land within an irrigation scheme is also not irrigated due to urbanization, adherence to rainfed agriculture or other socio-economic aspects (Özerol et al. 2012), with an average irrigation ratio of about 65% countrywide. In Egypt there is no clear statistics for the New Lands, but a substantial part of it is abandoned or only partly irrigated due mainly to a lack of irrigation water.

In Italy, since 1970 the irrigated land declined with regard to irrigable land, and is currently only two thirds of the latter. The two main reasons are low water availability and low profitability of irrigated crops, driven by changes in the Common Agricultural Policy that reduced the profitability of fruit and vegetable but also increasing regional competition. In France, low rates of use of irrigation facilities (68% in 2010) reflect changes in rainfall and crop subsidies, urban expansion (e.g. SCP company) or a planned water demand that never fully materialized (the Bas-Rhône Languedoc company). In Catalonia, the failure of the ambitious Segarra-Garrigues Canal (12,000 ha irrigated out of the 95,000 ha planned), in contrast with other successful past experiences in Spain, suggests that the time for these large-scale projects has passed.

Although Morocco is subject to the same problems, it illustrates that insufficient availability of surface water can be partly compensated by resorting to groundwater as a complement. Irrigation is largely maintained but sources up to half of its water from aquifers in a non-sustainable way.

3.3 The rallying call for modernization

In the face of water shortages, the promise of a 'technical fix' provided by micro-irrigation and interventions like canal lining has been extremely attractive for politicians and managers (Venot et al. 2017). Israel has invested in drip-irrigation since the 1960s and the technology now amounts to 80% of the irrigated area (the remaining being under sprinkler). Spain and Morocco, in particular, have designed ambitious multi-billion euro programs to 'modernize' irrigation and 'save' water (1.16 Bm^3 at an estimated cost of €7.3 billion for Spain, and 0.8 Bm^3 at the cost of €3.7 billion for Morocco), and Egypt's Ministry of Agriculture has also floated proposals for massive technological shifts, as part of a 640 billion pound[6] agricultural strategy until 2030.

In Algeria, Tunisia, Italy or Turkey water-saving technologies have also been encouraged and subsidized by the state. In Turkey grants support 75% of the costs for collective pressurized irrigation applications and 50% of within-parcel modern pressurized irrigation investments but the use of water saving technologies is far under target because of increased costs due to land fragmentation. In Italy the investments required by these technologies have been mainly supported by Rural Development Policies, covering up to 60% of the costs. The same applies to Tunisia. In Morocco, subsidies for drip irrigation from the 'Green Morocco Plan' now reach 80%-100% according to the type of farm. Spain modernization programs (which supports between 40% and 100% of the investments) and farmers' own strategies have now resulted in 44% of the total irrigated land being under drip. This also includes sprinkler systems that may be better suited for certain crops and

[5] The ratio of the area harvested every year to the area equipped with irrigation facilities.

[6] Around $120 billion, in 2010 values. This is only half of the investment envisaged, the other half being expected to come from the private sector.

terrains (e.g. the modernization of networks in Aragon, Spain and France, where sprinkler systems dominate).

It is important to note, however, that the spread of sprinkler and drip irrigation owes little to water scarcity, as generally believed. In France and Italy increasing labor costs and the ease of use are the main factors. In Spain, Ortega-Reig et al. (2017) have identified a double discourse, whereby while the administration and the government boards of the WUAs justify the investment for water-saving purposes, farmers attribute their interest in drip irrigation to labor saving/comfort and productivity. In numerous regions, the adoption of drip goes with an expansion of, or a shift to, high-value crops, mainly fruit trees and vegetables, which demand a better application of water. Drip also allows for fertigation and altogether improved agricultural practices generate substantial increases in yields and better uniformity of produce (an important standard of supermarkets' demand, notably in the fruit and vegetable sectors of EU countries). But this also means that such intensification must enjoy a secure source of water compatible with frequent irrigations. This is why the shift to micro-irrigation is largely associated with (individual) groundwater-based supply where, in addition, pumping from well may also directly provide the pressure needed to serve the distribution systems (frequently, though, farmers will build an intermediary on-farm storage from which they will pump again to distribute water).

What drip irrigation really does to water has, in recent years, been the object of much debate and controversy in places such as California, China, Australia, Spain or Morocco. First, it has been observed that for a variety of reasons farmers (in general smallholders) did not always reduce the amount of water applied to their plot. Second, even where this is the case it appears that the amount of water effectively consumed at plot level is basically unchanged, and even sometimes increased due to the large increases in transpiration allowed by better and more frequent application of water (Perry and Steduto 2017). Third, the shift to drip irrigation is often accompanied by: a) a shift to more water-consuming crops, b) a densification of tree plantations, c) an extension of the cultivated area made possible by reduced per hectare application rates (the so-called rebound effect)(Ward and Pulido-Velazquez 2008, Playán and Mateos 2006, Willardson et al. 1994). The combination of these effects can be observed in Morocco (Molle and Tanouti 2017), although there are also other Mediterranean cases where existing plantations are left untouched (Soto-García et al. 2013; Sanchis-Ibor et al. 2017a). It is apparent that drip and agricultural intensification in general do the opposite of what decision-makers expect or announce: they do improve productivity and reduce labor costs and drudgery, but do not reduce water *consumption*. For some reasons, Turkey, Italy, Tunisia and even Israel have so far largely avoided this debate, despite its relevance for regions such as the Konya closed river basin in Turkey, for which the literatures is confined to plot-level technical issues.

Not all the cases of irrigation expansion are associated with a *shift* to drip irrigation. In the vineyards of southern France, for example, irrigation has tripled since 2000, stimulated by subsidies and wine market requirements, despite the reduction in the total vineyard area. Similar processes have been observed in old rain-fed areas in Spain, such as the olive grove areas of Andalusia, where drip is only part of a strategy to increase production, with negative effects on groundwater overexploitation and energy consumption, or in Valencia, where the Basin Authority conditioned the expansion of citrus irrigation into rain-fed areas upon the installation of pressurized distribution network (Sese-Minguez et al. 2017). Drip is, in such cases, the vector for irrigation expansion and, despite being often considered as a demand-side measure, the vehicle to perpetuate old irrigation expansion policies, particularly in closed basins.

More generally, modernization or rehabilitation of existing infrastructure are made necessary by their degradation, the intent to better and volumetrically control supply, or to deliver water under pressure instead of by gravity. Morocco, for example, has undertaken to transform part of its large-scale gravity schemes (with a total of 200,000 ha) into collective piped networks with a pressure allowing the use of drip irrigation at the farm level. In Spain, the second pillar of the EU Common Agricultural Policy (rural development) still prioritizes the policies of irrigation modernization in the

Regional Development Plans (RDP), even though the budget is going to be reduced. In Spain, or in France, telecontrol has been widely used to monitor and operate irrigation structures in real-time from conveyance canals and in-line reservoirs to water delivery networks and drip or sprinkler irrigation systems. Consequently, labor requirements have been reduced and working conditions have improved in farms and irrigation districts.

Modernization also relates to improvements at the farm level. Aside from the spread of micro-irrigation discussed above, field moisture monitoring systems are being adopted in countries such as France, Spain or Israel. They provide growers with real-time computerized field monitoring capacity. Remote sensing or drones are also proving to be useful in the identification of spatial heterogeneities at the (large) farm level and the development of precision agriculture. In sum, while better control of water quantity and quality, and of nutrients, is enhancing land and water productivity, and generally reducing the volumes of water applied, better technical control also has to go with a better control and predictability/reliability of supply, as well as with improved technical services and market linkages (Playán and Mateos 2006).

When one zooms out to the scale of the irrigation system, aquifer or river basin it is frequent that no water is 'saved' since return flows have already been appropriated. This is notably the case in systems over quaternary aquifers where seepage either replenishes the aquifer (often intensively tapped through wells) or goes back to the river system. 'Savings' estimated by cross-multiplication on efficiency coefficients before and after adoption of drip (Blinda 2009), are illusory. Even more so when these 'paper water' savings are transferred to other areas, as happened with the water 'saved' through the modernization of traditional irrigation systems in the Júcar basin planned to be transferred to the Vinalopó basin.

Beyond this efficiency debate, the introduction of pressurized irrigation might be the most significant technical change in the Mediterranean region since the Medieval Arab Agricultural Revolution. Microirrigation is also changing norms and practices in WUAs, with traditional farmers' knowledge being replaced by engineering principles and centralized irrigation water management and decision-making, as observed in Spain (Ortega et al. 2017). In Morocco, Benouniche et al. (2014) have identified processes of "bricolage", by which farmers manipulate the drip kits and perform their own technical solutions to adapt the technology to their needs. Modernization may incur a loss of cultural heritage in some ancient hydraulic systems. This has raised some public concern, which is slowing down or stopping the advance of drip in some traditional waterscapes. In Spain, in some historical irrigation systems farmers resist to the adoption of microirrigation, defending the natural flow of water as a matter of identity and a contestation of the powerful notion of modernization.

3.4 Irrigation and user participation

In 1846, Catalan lawyer Jaubert de Passà published his "*Recherches sur les arrosages chez les peuples anciens*", a unique four volume global compendium on irrigation. Rooted in his experience with communal irrigation in the French Pyreneans, he describes at length the virtues of self-management in ancient communal irrigation (Ingold 2008, Mollard 2004). Mediterranean countries all have a rich history of small- to medium-scale irrigation systems, largely developed endogenously, which have often endured up to these days.

In Italy, nearly 500 Reclamation and Irrigation Consortia (*Consorzi di Bonifica e Irrigazione*), associations of landowners involved in collective water and land management, manage most of the Italian irrigation. The consortia of Northern Italy mainly derive from spontaneous associations of landowners, whether small (in the alpine valleys) or large (in the Po valley), while those from the Center or the South are generally quite large and were established in the 20th century. They have management and maintenance duties and a public juridical personality to share the costs and collect related payments. In France, approximately 2,000 irrigation user associations (ASAs) manage a total of over 300,000 ha of irrigated networks of all sizes, some dating back to 500 years ago. ASAs have

considerable decision-making autonomy in terms of the operating rules governing the relationships between members and the operational management of the area but are subject to a strict regulatory framework and supervision from the state (notably with regard to financial management). In Israel, Water associations are regional cooperatives whose members are *kibbutzim* and *moshavim* (settlement communities). These water associations are also platforms for political activity and negotiations with the public officials on issues such as quotas or water rates. In Spain, numerous irrigation communities (*comunidades de regantes*) have their origin in the Islamic period (*jmaa*) and were recognized after the *Reconquista*, before being regulated by the modern state in the 1866 Water Law. Today, more than 7200 communities manage collective irrigation systems, encompassing the 80% of the irrigated lands. Most of them belong to FENACORE, their national federation. FENACORE acts as a powerful lobby and was also the promoter of the Euro-Mediterranean Irrigators Community (EIC), integrating associations from Italy, Greece, France, Portugal, Spain, Tunisia, Morocco, Egypt and Germany.

In other countries, despite an equally rich communal irrigation background, water user associations (WUAs) established in public schemes by the administration have been bedeviled by a number of difficulties and constraints (Ghazouani et al. 2012). In Morocco, the lack of willingness to empower associations is apparent and the law on WUAs lists servitudes and duties, while no autonomy, financial or otherwise, is granted. In Tunisia, 1253 GDAs are responsible to a varying extent for a total surface area of 213,000 ha of public irrigated areas. The technical and financial management of irrigation networks by GDAs and the performance of these groups in terms of service quality vary widely: problems such as water shortages, insufficient financing for major repairs needed, elite capture or political meddling, have triggered several successive reforms but not eliminated problems. In Egypt, comprehensive experimentation with WUAs at different levels –from the tertiary to the district level- as part of different donor-funded projects has not succeeded in durably institutionalizing a degree of participatory management. In Turkey, in the early 1990s DSI started to transfer O&M responsibilities to a variety of collectives according to a model of irrigation management transfer (IMT) inspired by the Mexican example and largely motivated by the intent to externalize costs onto users.

All in all, these experiences have not been very successful as the states (or their water bureaucracies) have been reluctant to devolve or share power, financial autonomy has been an elusive goal, and a top-down process of formation has rarely elicited viable collective action.

3.5 The water-energy nexus

Because water must frequently be lifted and/or pressurized (in the case of piped networks or farm-level sprinkler or micro-irrigation), many irrigation schemes come with substantial energy needs. When water first needs to be treated or desalinated, these energy requirements –and associated costs- quickly balloon. This also applies to interbasin transfers that come with pumping costs (e.g. Algeria or Tunisia), one main obstacle to the planned North-South Moroccan transfer.

Hardy and Garrido (2010) observe that the modernization of irrigation in Spain has brought with it an increase in farm consumption of electricity, against a backdrop of rising energy prices. This general increase is caused by new irrigated areas, a shift from surface water to pressurized systems, although numerous groundwater-based farms decrease energy consumption when they adopt drip irrigation (Jackson et al. 2010, Sanchis-Ibor et al. 2017a). Likewise in Tunisia, various factors contribute to raising the energy bill: the deepening of wells and boreholes; adoption of energy-intensive irrigation techniques and increased regional transfers of water.

The rise in the electrical bill caused by modernization has sometimes prompted a financial support of the State to the agricultural sector. In Morocco, agricultural policies (notably the conversion to drip irrigation) have been designed with little consideration of their impact on the country's €10 billion energy bill (96% of Morocco's energy is imported), 13% of which on account of agriculture. In 2011,

total subsidies involved in energy consumption by agriculture amounted to €0.75 billion. In Italy, some Regional Administrations financially contribute to covering WUAs' O&M costs in order to offset the structural handicaps involving higher energy costs for lifting and distribution. In Spain, the national federation of WUAs organized massive public demonstrations in 2014 to demand, unsuccessfully, this type of subsidies for the irrigation sector.

Egypt's irrigated land probably forms the biggest pump station on earth. Both irrigation and drainage water is lifted, whether through one of the 600 large-scale pump stations or through close to 4 million individual pumps. Energy subsidies make up 70% of total state subsidies and therefore represent an outstanding financial burden.

Because of the importance of the groundwater economy for livelihoods and agriculture, policies to use solar energy to reduce groundwater pumping costs for users have been considered. Countries like Morocco and Egypt encourage and even subsidize the expansion of solar-based pumping, and some Spanish regions have recently included such subsidies in their modernization programs. However, Jordan has rightly anticipated the associated negative impacts on groundwater use and the Ministry of Water has so far brushed the idea aside. The recent report by FAO (2018) titled 'The benefits and risks of solar powered irrigation' – duly emphasizes that this option "if not adequately managed and regulated – bear the risk of supporting unsustainable water use" but nevertheless promotes it in contexts where regulation is precisely problematic.

4 Irrigation and its economic context

4.1 Investments and financial sustainability

As discussed above, the financial sustainability of public irrigation schemes and the recurring burden for state coffers have long been a key policy concern. Infrastructure deterioration and the need for maintenance of hydraulic structures and pump stations, desilting, dredging, weeding, etc. have taken their toll on state budgets. Solutions have included 'sharing' management and costs with users through participatory irrigation management (PIM) or more assertive Irrigation Management Transfers (IMT), most particularly, as far as the Mediterranean is concerned, in Turkey or EU countries.

The World Bank supported the idea of privatization in irrigation on the model of the utility privatization drive of the 1990s. But the recognition that large-scale irrigation systems are different from urban networks or power grids has percolated very slowly at best. It became apparent that the potential of irrigation for generating profit to a hypothetic private company taking over the management of a scheme was very low, as transpired for example in the feasibility study of the privatization of the *Office de Mise en Valeur Agricole* in Morocco. Farmers' ability-to-pay in such schemes is largely linked to the remuneration dictated by markets and this value is low for most major crops.

Emphasis has therefore been shifted to Public-Private Partnerships (PPPs) as a means of both involving the private sector in the financing and management of irrigation and favoring a type of agriculture that "can pay for a service" (World Bank 2007). That cash crops are frequently associated with individual groundwater-based irrigation suggests that they could expand to public schemes and generate a higher willingness- and ability-to-pay for water. But this makes light of the facts that horticulture expansion has limits (it represents only 7% of cultivated areas worldwide), and that capital-intensive agriculture is risky for farmers without capital (in particular in the face of pest pressure and market vagaries).

Commercial, climatic and political risks have been identified as hindering the adoption of PPPs, as could be seen in the case of the West Delta project in Egypt. In the Guerdane project, Morocco, a private company built and operates a pipe to transfer water from a dam to the investors. 48% of the

project costs have been shouldered by the state. Another project is starting in the Coastal Chaouia region, south of Casablanca, where the delivery service has been entrusted to a private company; and 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.

Social and economic risks have been observed in Spain, where the re-collectivization of irrigation management after privatization has been analyzed in the Jucar River basin (Sanchis-Ibor et al. 2017b). Drip irrigation has acted as a Trojan horse, facilitating the penetration of private companies into irrigation management, displacing farmers that had collectively (and successfully) managed irrigation systems during the last millennia, rising O&M costs and creating distrust and social disarray.

4.2 Irrigation water use and economic tools

Irrigation water pricing is a prominent tool of the EU Water Framework Directive. Intensely promoted in the 1990s, the idea was shifted to the backburner in the late 2000s[7], partly due to the recognition that the field of irrigation, especially large-scale irrigation, presented key differences with the urban water or energy sectors, where pricing tools have well documented applications (see Cornish et al. 2004; Molle and Berkoff 2007, for a full analysis of the reasons for the failure to achieve irrigation water savings through pricing).

In Spain, water pricing is based on public and private tariffs that are essentially what users pay for the delivery of water. Public prices include resource management fees for the regulation of surface or groundwater conducted by the State, on top of costs of amortization of the investments they have made, and O&M running costs. Tariffs and fees vary widely among Spanish irrigators as a function of the resource origin, its size, the method of water application, etc. They have never been used by the administration as a means of reducing demand, although this idea was brought to the National Water Council in 2006 but was widely refused by regional governments and water user associations' representatives. In Italy, Dono et al. (2012) note that for selected schemes applying a volumetric pricing would not appreciably increase overall efficiency and would especially redistribute income among farmers. Operating costs also reflect the size of the irrigated land more than the volume of water supplied, and inefficiencies are largely due to the oversizing of infrastructures and would therefore not be reduced by an increase in the price of water.

In Israel, water for agriculture has historically been heavily subsidized as a means of encouraging and supporting settlements. Despite strong lobbying, in 2006 farmers agreed to a gradual rise in the price of irrigation water that would reflect the average cost of water supply. At the same time wastewater remained subsidized so as to encourage farmers to shift to treated wastewater.

In Tunisia, the overall increase in both prices and the cost-recovery rate between 1990 and 2002 served to cover a considerable portion of the rising water system operation and maintenance costs. Prices were frozen as of 2002 because of the strong resistance among irrigation users, which had a considerable impact on the financial balance of the GDAs, weakening their ability to fund servicing and maintenance work. “Political interventions” regarding pricing, bypassing regulatory bodies, viewing minimizing water charges as a way of improving farmers’ revenues, has often had a negative impact on the sector. A similar situation can be found in Morocco, where tariffs were raised during the 1997-2006 period, also primarily for financial reasons. But raising prices sufficiently to cover O&M costs has proven 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".

Financial sustainability also features highly in Turkey, where WUAs depend on the fees they collect to survive financially and to pay their personnel. The proportion of fees that the associations can collect

[7] Comparison between the 1993 and the 2003 World Bank's water Policy Papers clearly reflects these changes.

from their users has increased from 40% to 60%-100% after the IMT reforms, but many associations are financially non viable, especially if they have pumping costs due to the privatization of electricity services (Le Visage 2015). In Egypt, there is no attempt to charge farmers for water and only users dependant on a same collective pump station collect money for O&M costs.

In sum, the main challenge with water pricing is the financial sustainability of both WUAs and infrastructures. In Spain, France, Italy, Turkey, Egypt (for collective pumps) and Tunisia WUAs can legally recover costs, or part of them, from users. Full cost recovery is rare and includes cross-subsidizing from other sectors, and in no case covers all environmental costs. High prices rarely promote water savings because the marginal value of water in terms of production is far higher than its cost to the farmer, especially in water-scarce settings; they may push farmers to shift to groundwater; economic studies invariably find that price levels that would achieve water savings would severely dent incomes and are therefore politically unfeasible (see Molle and Berkoff 2007, Chohin-Kuper et al 2014). The same applies to individual groundwater pumping.

Volumetric pricing, wherever technically achievable, and where supply is sufficiently controlled so that an on-demand system can be established, can be used with increasing block tariffs to both allow and discourage the use of water beyond a certain established quota (e.g. Israel and some schemes in Spain, France or Italy). In specific cases where water costs are very high (deep groundwater pumping or desalinated water) use efficiency becomes paramount but is already a feature of the high value commercial agriculture which can endure in such conditions (e.g. Almeria, Spain; Massa basin, Morocco). Water tariffs have also been used by some Spanish WUAs to incentivize the adoption of drip irrigation, penalizing farmers who are reluctant to abandon gravity practices.

While direct administration of water prices can at best achieve recovery of O&M costs, and sometimes of additional 'resource management' and even part of investments costs, water use is sometimes affected by energy prices. Energy prices are amenable to regulation but, in general, they are subsidized for agricultural water use rather than used as a lever.

Other potentially interesting economic tools have been noted. They include Temporary Right Transfers in Spain, and temporary buy out of rights in France or in Spain, where farmers are compensated for not using the water they are entitled to. This mechanism has been criticized because of the risk of creating potential “waterowners” in regions where agriculture is decreasing. In Spain, despite the initial enthusiasm for this mechanism, water authorities are now closely reviewing (and adjusting) WUAs’ water rights, reducing the scope for such exchanges.

4.3 Corporatization of irrigation?

A notable trend is observed with regard to the development and promotion of capital-intensive agriculture. "Plasticulture", with intensive use of greenhouses, plastic mulch, lines of drippers, etc. and largely devoted to vegetables, or intensive fruit-tree plantations (e.g. citrus, vine, guava, stone-fruit trees,…) has been developed in different contexts by both local investors (e.g. Israel; Almeria, Spain; Jordan Valley), but also national or foreign corporate capital (e.g. Egypt's New Lands, Morocco's oases, Algeria' Sahara, etc) (Dixon 2017). Plasticulture has now expanded to most countries, creating agro-technological clusters in Almeria (Spain), Souss-Massa (Morocco), Albenga (northern Italy) and Southern Sicily, Demre and Kumluca and Southern Anatolia in general (Turkey); Tartous coast (Syria); Halba (northern Lebanon); or Israel.

This type of agriculture has been discursively promoted as 'modern' and 'efficient' in countries like Egypt and Morocco, where performance in terms of water productivity, efficiency but also contributions to export and the balance of payment are underlined. But emphasis on 'efficiency' performance often results, purposefully or not, in sidelining the other two dimensions of IWRM - equity and environment- and in belying the conventional consensus that the three 'pillars' of IWRM have to be considered and reconciled. Corporate agriculture often benefits from preferential, state-facilitated, and frequently state-subsidized access to land and water resources. In Guerdane,

southern Morocco, water has been piped out of the main valley to 10,000 of fruit trees mainly belonging to outside investors. Everywhere, deep groundwater pumping impacts water tables to the detriment of small farmers who do not have the means to deepen their wells.

4.4 Changing markets and incentive structures

The spread of liberalism in the last decades of the 20th century has increased the internationalization of Mediterranean agricultures and has also remodeled the public support to the irrigation sector. These processes have resulted in different impacts among the Mediterranean countries, depending on the type of agricultural production, farm structure, capital availability, and other regional and sectoral conditions. There has been much debate, often ideologically biased, about the results of these processes. The only evidence is that there have been winners and losers, and that losers are mainly the weaker smallholders.

In Israel this turn towards international markets has been largely successfully managed. With the opening to the international markets, the drought periods in the 1980s and, later, a reduction in the subsidies for water as well as in the political clout of the agricultural lobby in the Parliament, farmers had to adapt and innovate, developing an export-oriented high value agriculture irrigated with drip (Kislev 2013).

The nations of the EU also progressively increased their exposure to world markets since the McSharry reform of the CAP (1992), and particularly after the Mid-Term Review of 2003, which decoupled subsidies from production and almost totally reduced the import levies to fulfill WTO standards. Despite a still significant level of protection (Producer Support Estimate indicator is still 21%, against 39% in the 1980 decade)[8], the decreasing number of farms and the slight increase in the average size of agricultural holdings, numerous European farmers are unable to compete satisfactorily. In Spain, Italy and France, the viability of irrigated agriculture is threatened by the low remuneration of productions in the national and international markets (Atance 2013).

Reliance of migrant workers is high in Italy and Spain, and also in Portugal and Greece, because of the need for reducing costs and the lack of interest from locals, despite high unemployment rates (see Corrado et al. 2017). These contingents of workers are underpaid, suffer from precarious labor conditions, and in many cases do not have residency permits, which makes them socially vulnerable. This phenomenon, frequently made invisible, constitutes a clear form of social dumping (Laurent 2013) that also takes place in other Mediterranean countries. Nearly half of all Syrian refugees arrived in Turkey work in farms for very low wages (Erkturk 2017) and Israel, after the second Intifada, has replaced Palestinian workforce by other migrants –mainly through the Thailand-Israel Cooperation on the Placement of Workers–, whose precarious conditions have been denounced by several NGOs (HRW 2015).

Changes in the supply chain of fruits and vegetables, where small operators tend to be replaced by large companies vertically integrated with retailers, have affected family agriculture (Petriccione and dell'Aquila 2011), while the growing competition from southern countries has weakened their position in national markets (Malorgio and Hertzberg 2007; Nomisma-Unaproa 2016). Farmers' associations frequently organize demonstrations against the importation of foreign agricultural products, publicly complain about price volatility, and demand policies that provide a more equitable distribution of the added value in the commercialization chain (García Álvarez-Coque and Martínez 2013).

Technology has facilitated recent improvements in productivity (sprinklers and drip), but has also caused a dependence on agricultural inputs, particularly energy, that is detrimental in a context of low agricultural prices. However, we lack of quantitative studies analyzing the economic impact of such technologies at the landholding scale, because researchers have concentrated their efforts on

[8] 17% for Israel and 27.9% for Turkey, according to the OECD (2017) estimations for 2015.

the analysis of water costs or water productivity, often not considering all the factors involved in the farming budget. This is a relevant issue, because in France and Spain, many farmers consider irrigation as pivotal for maintaining competitiveness and in Spain elderly farmers frequently admit they would have abandon agriculture without such 'modernization'.

The swings of the CAP during the last decades, and particularly, the changes in the Common Market Organizations, have induced substantial changes in irrigated landscapes. Maize subsidies played a major role in the expansion of irrigated maize in France, and the 2005 reform of the Common Market Organization for sugar has brought to zero the demand for sugar beet in many irrigated areas of the center and south of Italy. Similarly, the abolition of milk quotas has reduced milk production, and has indirectly caused a decrease in the demand for corn, affecting several Italian irrigated districts.

In Egypt, during the decades of 1980 and 1990, under the influence of donors and development banks, priorities shifted towards price liberalization and private investment in agriculture. There is no consensus on what these reforms have eventually produced but the capital-intensive export-led agriculture in the New Lands neither resulted in significant job opportunities nor in increased food security. Linking small farmers to markets through contract farming has also been little successful.

In Egypt and Morocco, but also more generally, a dual model has been consolidated, with a 'modern' capitalized high-tech sector, and a traditional smallholders sector supposed to be transitioning towards a 'modern' agriculture (Faysse 2015; Akesbi 2014). The future of both sectors is linked to the evolution of factor prices, market conditions, and public support to irrigation, including expansion and modernization. Market risks are well illustrated by seasonal dramatic drops in prices, for example of tomato and citrus in Morocco, or various vegetables in Spain.

5 Policy-making and institutional dimensions

5.1 The policy process

Many irrigation reforms have been conducted worldwide in the 1980s and 1990s (Mollinga and Bolding 2004). After the turn of the century, the topic has somehow become less fashionable, needed or urgent, depending on the viewpoint considered. Earlier reforms were largely motivated by the need of financially strapped states to divest part of their recurring rehabilitation and O&M costs onto users, combined with the frustration of donors in front of the perceived low performance of the sector and repeated rehabilitation needs. They were also part of a more general "rolling-back the state" neo-liberal context and a period in which both economic tools and "participation" came to be seen as the major solutions to the ailments of the sector (Mollinga and Bolding 2004; Molle and Berkoff 2007). More recent global policy emphasis has shifted to privatization, PPPs, and supporting large-scale private investments.

Institutional change in the irrigation/water sector has been found to be seriously under-researched (Mollinga and Bolding 2004). This applies to issues such as the role and strategies of hydraulic bureaucracies, the constant reshuffling of ministries and restructuration of the administrations in charge of agriculture, irrigation, water, the environment, public works, etc., participatory irrigation reforms, the role and transfer of 'policy models', or the pervasive and glaring gap between formal policies and laws on paper and their implementation or enforcement on the ground. Most countries do "tick all the boxes" and have incorporated in their legislation participatory management, economic tools, river-basin planning or organizations, user-pay or polluter-pay principles but these remain largely cosmetic and/or little effective in most countries.

While this volume did not either undertake original research on such issues, the fact that a large part of the literature is confined to the description of formal regulations, implicitly assuming their overarching importance, blinds us to the multi-faceted dimensions of policy-making, and in particular to the politics of reform and policy-making.

The role of 'hydraulic bureaucracies' in the evolution of the irrigation sector is under-documented, although it is well established that bureaucratic interests are an essential part of it (Molle et al. 2009). We observe a resilience of the 'hydraulic bureaucracies' in the Mediterranean, whether they are under the Ministry of Agriculture (Spain since 2008, Tunisia) or a water or energy ministry (Egypt, Lebanon), but even where these have been put under or pooled with the environmental administration (Morocco, Spain between 1996 and 2008, Turkey between 1991 and 2011). For example, in Morocco Tanouti (2017) shows how the hydraulic bureaucracy has preserved its interests despite being put under an administration in charge of the environment. However, while countries like Morocco and Turkey still have a substantial dam/irrigation building program, in most countries the lack of adequate sites and scarce funding have clearly curbed the historical 'hydraulic mission'. Large-scale public irrigation, with the exception of the GAP in Turkey, is now mostly a thing of the past.

Little is known also about the role of the private sector. Many studies on Egypt show the link between irrigated land expansion and the clientage practices that are at the root of state building and reproduction, notably through providing opportunities for capital accumulation in land reclamation and agricultural development (Dixon 2013, Roccu 2013). In Morocco, national or international companies investing in irrigated agriculture also carry substantial political power. In Algeria, some powerful people are also able to invest in desert agriculture.

5.2 Policy contradictions

Lack of "alignment" or sectoral contradictions are pervasive in the fields of agriculture in general and irrigation in particular (Özerol and Bressers 2015). They are linked to antagonistic objectives pursued by the different ministries despite frequent claims that 'coordination' and 'integration' are achieved through various inter-ministerial committees or high-level agricultural, or environmental, councils.

The most ubiquitous contradiction is that pitting against one another the water and agriculture administrations. This right hand ignoring what the left hand does is particular glaring in Morocco and in Egypt. In the former, the Plan Maroc Vert (PMV) powerfully thrust by the Ministry of agriculture promotes the expansion and intensification of irrigated agriculture, even in areas where water tables are already dropping by one meter a year due to overexploitation. The disregard for both water resources and the environment illustrates an on-going regain of political power of the agricultural sector which can perhaps be partly ascribed to both the importance of the sector in the social stability of the country and the private interests that have invested in it. In Egypt, the Ministry of Water Resources and Irrigation and the Ministry of Land Reform and Agriculture have disputes about various issues, including on what is the potential for water saving, the latter promising to "modernize" agriculture and save 12 Bm^3, despite the former making explicit the impossibility of such target.

Policy contradictions are also apparent with regard to subsidies that promote certain crops that increase water use. This has been the case, for example, with EU subsidies to maize (France, Spain) although since 2003 subsidies are decoupled from farmers' production decisions through a system of direct payments. A recent report of the European Court of Auditors (ECA 2014) has concluded that, on the one hand "delays in the implementation of the WFD have, as a matter of fact, hindered the integration of water policy objectives into the CAP" while, on the other, "monitoring and evaluation systems both directly related to the CAP [...] did not provide the information necessary to fully inform policymaking as regards pressures on water coming from agricultural activities".

Integration between irrigation/water issues and environmental dimensions is also very limited in most countries (Jordan and Lenschow 2010). Examples include environmental impacts of stream and aquifer overexploitation on river base flows (e.g. Spain or Greece), or springs and wetlands (Azraq oasis, Jordan; Marrakech Palm grove, Morocco; Ichkeul lake, Tunisia; Konya Lake, Turkey; Tablas de

Daimiel, Spain; Lake Karla or Argolis, Greece, etc), and coastal areas (saline water intrusion in all countries).

A review of countries in the Arab world has identified a "lack of integration between sectoral water-related policies which leads to fragmented programs and inefficient utilization of technical capacities and financial resources", together with an absence of social and economic dimensions in developed water policies and insufficient awareness on environmental issues (GWP Med 2007). This is a pervasive problem that has no simple rational solution because lack of integration also reflects turf battles between ministers and ministries in the attempt to gain a bigger slice of the state budget and maximize bureaucratic or political power.

In Turkey, "water and environment affairs are managed under different ministries [which…] has caused some difficulties in executing water and environment works because of duplications of their duties and responsibilities" (Delipınar and Karpuzcu 2017). DSI remains the dominant administration in the Ministry of water, with little integration with the Ministries of agriculture and of the environment (Özerol et al. 2012). In Egypt, these three sectors also come under three distinct ministries, marked with hyper-centralization, vertical integration, and problems with knowledge-sharing and cross-sectoral coordination. In Morocco, the Economic, Social and Environmental Council 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 and insufficient coordination between departments concerned with water.

One solution to inter-ministerial competition that is often proposed is to merge water and agriculture in the same ministry (as in Tunisia or Turkey, before 2011), or water and environment (as in France or Italy), or the three together (as in Spain). This does instill some consistency in overall water management but does not provide any check and balance and irrigated agriculture may still be supported beyond the availability of the water resource. The example of France shows that environment and development (*aménagement*) can be put in the same ministry but that resolving tradeoffs internally requires ad hoc mechanisms and balancing acts between stakes and sectors (Lascoumes 2014).

5.3 Political dimensions

Chapters in this volume cover some institutional and policy changes and briefly hint at a number of political factors that interplay with irrigation policy elaboration and implementation. Already mentioned are the interests of the state in announcing irrigation projects and water resource development projects that are presented as unquestionably desirable or national priorities. A recent illustration is President Sisi's "1.5 million feddan project" that seeks to expand groundwater-based irrigation in Egyptian deserts and has been accompanied with much hype, as had been earlier versions of the same ideas since Nasser's time. In Turkey, state authorities assert that an additional 2 million jobs will be generated once the targeted areas have been developed for irrigation by the year 2023 and benefits are presented as unquestionable while negative impacts, or the fact that one third of irrigation facilities are currently idle, are glossed over (Özerol et al. 2012).

An important political element of irrigation/water policies are electoral concerns from either the state or MPs and other politicians. In the past MPs have been instrumental, for example, in opposing water pricing policies (e.g. Egypt) or hikes in tariffs (e.g. Tunisia, Jordan). Energy subsidies are also maintained for similar reasons and their potential for triggering social unrest in case they are discontinued. Crucially, political considerations have worked against regulation of groundwater, which largely explains the current worrying overall situation of overdraft. Access to groundwater is not only the compensation and the alternative for farmers in public schemes who do not receive adequate supply (e.g. Algeria or Morocco), but also a "livelihood escape valve" in that it provides an opportunity for raising rural incomes and reducing poverty (Kuper et al. 2016). In the volatile post-

2011 context in the MENA region, controlling illegal wells and other violations, such as urban encroachment on agricultural land (e.g. Egypt) or water theft (e.g. Morocco), has become close to impossible.

Politics also speak to the relative political power of the agricultural sector, which may reflect the interests of capital-intensive private farming, the social and employment importance of agricultural activities, or (in Europe) the need to maintain a minimal activity in rural areas, whether for "landscape management" or sustaining public services. The sectoral weight and political clout of agriculture, combined with the weight of hydraulic bureaucracies and/or the development drive of the ministry of water/agriculture, have in general been quite high in the Mediterranean, although they have certainly declined in the last three decades. This is well illustrated by the case of Israel, where the crises revealed by the 1989-91 and 1999-2001 droughts laid bare the fact that over-exploitation of water was the outcome of longstanding policy to deliver subsidized water to colonies to encourage and support settlements, and of an impasse between the agricultural lobby, which prevented an increase of water rates for agriculture and a decrease in supply, and the Treasury, which blocked desalination. In 2006 the Water Commissioner, originally under the Minister of Agriculture, was replaced by a Water Authority. The Authority is responsible for the management, operation and development of the water sector and is placed under the Ministry of Energy and Water, reflecting the shift in water policy away from irrigation and a weakening of the agricultural lobby. Such a change can also be witnessed in Jordan, where policies now seek to reduce the agricultural use of groundwater in ways that were not possible 20 years ago (Al-Naber and Molle 2017).

The political clout of the agricultural and/or irrigated sector remains high, in a sheer contrast with the contribution of the sector to national GDPs. Agricultural lobbies remain strong in Spain and France, for example, and also in countries where capital-intensive export-driven agriculture is benefiting powerful actors and is promoted by the states (e.g. Turkey, Egypt or Morocco). In Spain, the Spanish government and the agricultural trade unions have fought maintaining the status quo in the internal distribution of the European subsidies, so that the irrigation farmers are receiving an economic support significantly higher than the rain-fed producers.

6 Challenges ahead

1.1 Quantitative easing/squeezes

In the Mediterranean, many river basins are closed and many aquifers over-exploited, with the annual volume of water consumed sometimes exceeding the average annual available water. Because such systems present a very high degree of water recycling, it is only possible to restore a degree of sustainability through a reduction in consumption (evapotranspiration), which explains –as discussed earlier- the limits to what can be achieved through demand management. In such a situation there is a need for stricter volumetric management of water resources. This has implications in terms of data collection, monitoring and evaluation, and research, all of which are at present much under-developed with regard to needs (Chohin-Kuper et al. 2014).

The inexorable squeeze of agricultural supply discussed in §2.2 has generated calls for volumetric management by the EU, with a stricter integration of irrigators, whether individual or collective, in their respective river basins as a means of enhancing control over water quality, minimum flows or floods. In France, it is too soon to evaluate how OUGC (*Organisme Unique de Gestion Collective*) will handle the annual/monthly amounts of water they are granted and asked to apportion among members, especially in times of shortage when this volume is reduced. Spain also shows cases of enhanced volumetric management, like for example in the eastern Mancha.

In non-EU countries, data collection is insufficient and confuses decision-making (MED-EUWI 2007). In Morocco the official number given for private groundwater-based irrigation (441,430 ha), the most

dynamic variable of the water sector, is the same since 2004… In Egypt there are often differences on water or crop data between official reports and their overall consistency appears questionable when one attempts to establish the water balance of the Nile delta (Molle et al. 2018). In Jordan official statistics point to a stable groundwater abstraction in the Highlands along the past 30 years, while Agricultural statistics indicate that the cultivated area has doubled (Molle et al. 2017b). Yet, analysts often overlook that collecting data such as land or water use is extremely demanding and costly, much beyond the capacity of most agencies, not to mention occasional data 'massaging' when they point to the wrong direction and are politically unpalatable.

The other side of the quantitative squeeze is the 'quantitative easing' that is likely to remain an attractive policy option from a political point of view. On-farm storage in France is now given priority and has relatively limited impacts (filling takes place in winter and use in summer). But large-scale transfers or desalination, notwithstanding the potential of treated wastewater, are still on the drawing board, especially in Morocco, Algeria and Turkey. They have considerable implications in social and environmental terms, capital investment, and energy consumption among other aspects.

6.1 Where is the environment?

As mentioned above, the massive mobilization of water resources, the fast expansion of irrigation over rain-fed lands, and the intensification of agricultural practices have jeopardized water resources –in terms of quality and quantity-, and altered numerous ecosystems. The roster of landscapes degraded or destroyed by irrigation expansion and intensive agriculture include all types of aquatic ecosystem and all Mediterranean regions.

Wetlands, frequently located at the end of the hydrographic systems and extremely sensitive to changes in the water budget, tend to receive the accumulated impacts of agricultural overexploitation and pollution. This is the cause of the recent crisis of the Mar Menor in Spain, the Ereğli and Eşmekaya reedbeds in Turkey, or the Sidi Moussa-Walidia complex in Morocco, where over-fertigation and pesticides are causing groundwater pollution, while water withdrawals for irrigation reduced the wetland by 21% between 1957 and 1991. The Dead Sea and several other inland lakes (e.g. in Tukey) are slowly drying up. In most cases the creation of protected areas is proving to be insufficient to preserve endangered ecosystems and their associated biota. Other soil- or water-quality related challenges include the pollution of rivers and aquifers by nitrates (causing public health problems and incurring treatments costs), soil salinisation (e.g. Tunisia), or waterlogging due to excess irrigation and to lack of drainage infrastructures (e.g. in Turkey).

Environmental preservation therefore stands up as a major challenge at a time when socio-political conditions push governments to give priority to production and the provision of livelihoods rather than to considering water as an ecological asset. In the EU, the control now imposed by the WFD and the priority given to the conservation of aquatic ecosystems constitute an enormous challenge for countries where a large water demand for irrigation has already created significant water scarcity and water quality problems (Albiac 2006). The WFD is demanding, but at the same time a necessary lever to move administrations that have historically faced difficulties with the enforcement of their legislation on groundwater control or ecological flows.

6.2 Climate change

According to the IPCC scenarios, the Mediterranean basin is considered as a region particularly vulnerable to climate change (CC). Climate models outline a pronounced rise in mean temperatures and a greater recurrence of high temperature events. A significant decrease in precipitation due to increased anticyclonic circulation and the northward shift of the Jet stream has also been highlighted. The recently observed trends coincide with some worrisome temperature scenarios, but downscaling rainfall evolution is more difficult due to the complex orographic structure of the

Mediterranean basin (Giorgy and Lionello 2008; IPCC 2014). ET increase seems unquestionable, but the behavior of rainfall in the Mediterranean cells show more variegated regional patterns.

In Turkey, the average summer temperature of the 21st century is 1.5° higher than that of the 1960-1970 period, and Spain and France have also undergone a 1°-1.5° rise in mean temperatures since 1970 and 1959 respectively (González-Hidalgo et al. 2016, Ribes et al. 2016). The pattern of rainfall change is regionally irregular. In Turkey, precipitation remains stable since 1980, while Italy has suffered a moderated decrease in the Thyrrenian regions (-5/8%), and a growth in the Adriatic (4%). In Spain, rainfall on the Atlantic side has decreased by 25% but Mediterranean precipitations have remained stable (Miró et al 2009). Changes in rainfall patterns, reforestation processes, and optimistic overestimation of water resources at the end of the 20th century have resulted in a downward revision of the water basin plans in Morocco and Spain, with decreases between 30% and 45% in the available water resources in the last 30 years (El Gueddari and Arrifi 2009; Avellà et al. 2014).

The 'double squeeze' affecting irrigation discussed earlier has prompted research on adaptive strategies (World Bank 2010). Beyond fine-tuning of irrigation to reduce evaporation losses and increase productivity, technical fixes –most notably drip irrigation and new supply augmentation options including wastewater reuse, desalination, and interbasin transfers– are favored by experts and administrations. CC has largely allowed a rebranding and greening of the old capital-intensive infrastructural hydraulic mission. Although Turkey's national adaptation strategy to CC (MEU 2012) places "expansion of rain-fed agricultural areas to irrigation" on the top of its list of adaptation actions, and Italy also included this measure in its national strategy, these policies seem to be based on flawed conceptions of irrigation efficiency and to be oblivious of the continued double squeeze underway, that rules out the extension of irrigation (IPCC 2014, Olesen et al 2011). We have discussed the reasons for such a preference and the risks attached to delaying the recognition of the natural limits of water use.

Today, while there is sufficient scientific evidence to support that CC is one of the most relevant challenges for the irrigation sector in the Mediterranean region, for many farmers CC ranks lower among their concerns (see Richard-Ferroudji et al. 2013 for France, and Ortega-Reig et al. 2018 for Spain), as they not only already have to cope with water scarcity but also because they primarily feel vulnerable to market and socio-political uncertainty.

7 Conclusions

From a common base of ancient small-scale communal irrigation systems, all Mediterranean countries have developed large-scale public irrigation schemes from the 1960s up until the 1980s. Physical and financial sustainability issues have motivated reforms in the 80s and 90s that included PIM, IMT and economic tools but these reforms largely failed. Although problems of deferred maintenance are still pervasive, interest of donors and priorities of governments have significantly shifted to supporting capital-intensive agriculture, technological (drip-irrigation) or supply-oriented (transfers, wastewater treatment, desalination) fixes, PPPs, and the development of groundwater, while issues of water supply and sanitation, water quality, and sectoral water allocation have become more prominent.

Loosely planned/controlled water resource development by both the state and individuals resulted in the closure of many river basins and the overexploitation of most major aquifers, with the annual volume of water consumed at the basin level sometimes exceeding the average annual available water. On paper, rational basin-level planning and other mainstream policy principles have generally been adopted and incorporated into legislation but implementation on the ground is hindered by a lack of both material means (for monitoring, data collection, sanctioning, etc) and political will: because water-short systems generally present a very high degree of water recycling, it is only

possible to restore a degree of sustainability through a reduction in consumption (evapotranspiration) by certain users, which explains the associated political difficulties.

Much less public money is invested in irrigation, despite food security concerns in some countries, but support to the sector is manifest through subsidies which signal a still significant political clout of agriculture in most countries. Capital-intensive export-oriented irrigated agriculture –including plasticulture- is promoted for its economic virtues, sometimes to the detriment of small-scale 'traditional' agriculture, but its social relevance is weak and its water footprint locally high. Market integration up to fast foods, supermarkets and export channels, with strict requirements in terms of quality and caliber, also favors the former over the latter. While some small farmers or local investors succeed in tapping niche markets the majority is sticking to a (relatively stable and extensive) low-benefit farming system for lack of know-how, information and capital to face the much higher risk of cash-crop farming.

Irrigation technology shows advance in remote control, micro-irrigation, fertigation, on-farm storage, precision farming with the use of drones, GIS and remote sensing. Largely subsidized water-saving technologies enhance productivity and reduce labor needs but rarely deliver in terms of water economy (*consumption*, often confounded with application). These techniques come with added capital and maintenance costs and are ill-adapted to fragmented, small-sized de-capitalized farms with gravity irrigation. The low level of infrastructure use, for a diversity of factors ranging from water shortage, poor profitability of agriculture, and risk to urban encroachment, salinisation, or optimistic planning signal the various threats and difficulties faced by the public irrigation sector. In contrast, the vibrant groundwater economy almost obscures the fact that it is based on declining stocks and therefore largely unsustainable.

Also noteworthy is the dire lack of reliable/updated data and the critical lack of in-depth research on land and water use dynamics, as well as policy-making, at a point where overuse of water calls for a more quantitative data-intensive management. But beyond data, irrigation systems are too often perceived as merely technical devices, obfuscating their systemic nature and linkages with economics and politics at various levels (Lankford et al. 2016). With a 'double squeeze' exerted by environmental constraints and growing domestic use, combined with declining and more erratic precipitations, irrigation will struggle to keep the same level of abstraction, although wastewater reuse is already showing its potential in assuaging this pressure, re-allocating to agriculture the water that had been taken away by cities.

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