Chapter 19

Implications of the modernization of irrigation systems

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ABSTRACT: This chapter looks at the relevance of an *ex post* analysis of the National Irrigation modernization programme implemented in Spain, possibly the largest in terms of surface area and investment in the whole of Europe and one of the largest programmes in the world. This plan was a state led effort to increase water efficiency in irrigation and generate water savings at plot and basin level, particularly to reduce water stress during drought periods. This was within a paradigm where irrigated agriculture had traditionally primed over other economic activities and water uses, and which promised the achievement of substantial water savings. There is now some evidence, after the completion of the programme, that planned water savings have not been met, and in some cases the increase in water efficiency application seems to have entailed an expansion in irrigated land and/or some crop changes, leading to potentially a higher overall local irrigation water consumption. However there are other unintended consequences and in some cases co-benefits in terms of reduced use of fertilisers due to fertirrigation, and better traceability and control on water use due to technological improvements. Yet the lack of reliable and consistent information on the actual aggregated consequences of this large public investment programme highlights the need for a detailed assessment on the consequences and logic of the modernization process. A set of indicators and a range of ways to implement these programmes are suggested to help identify and make a balance of the results *vs* the investment required, with views to a future modernization projects.

Keywords: modernization process, unintended consequences, water savings, water efficiency, energy efficiency

1 INTRODUCTION

This chapter offers an *ex post* analysis of one the largest irrigation modernization programs undertaken at national, European and global scale, which is conceived as part of a new turn in water policy towards demand management measures. Complementing previous emphasis on increasing supply through e.g. reservoirs and transfers, irrigation modernization has become a major thrust of Spanish water policy in the last 15 years. The chapter looks at the central role irrigation plays in Spanish water policy for two reasons: first, to trace its historical and cultural importance dating back to the 19th century; and second, because of the volume that irrigation represents for the Spanish water budget, consuming around 70% of water, and thus central to any debates or discussions on saving water. Examples of such debates are whether to leave more water for the environment or how to re-allocate water to other productive sectors, like energy and solar-thermal plants (see Chapter 14), tourism or public water supply. In order to analyse the intended and un-intended consequences of a major public investment programme for water efficiency and water savings, the chapter is based on a number of methods: literature review, in depth expert interviews, the analysis of data on the implementation of these plans, some specific case studies and methods to evaluate *water efficiency*, *water savings* and *water accounting*. This chapter complements other previous studies on this topic (Berbel & Gutiérrez, 2004; Camacho Poyato, 2005; Cánovas, 2008; Cots, 2011; Rodríguez-Díaz *et al*., 2004; Varela-Ortega, 2006) and is a shorter version of separate paper (López-Gunn *et al*., 2012).

2 THE LOGIC FOR IRRIGATION AND ITS MODERNIZATION IN SPAIN

In Spain the hydraulic paradigm permeates water-related decision making and policy frames. An expert interviewee, the Ex-Deputy Director for irrigation, pointed out that within this paradigm, agriculture (together with hydropower) has been – historically for valid reasons – a privileged user (Garrido & Llamas, 2009). A hard economic crisis in the end of the 19th century created tension between a growing bourgeois society amidst a largely rural and illiterate country. Water thus became a symbol of prosperity and modernity, and irrigated agriculture was seen as pivotal for change in a rural Spain (López-Gunn, 2009). Meanwhile in the Spain of the 21st century irrigation is now center stage because water has many productive uses, of which irrigation is one. In an urban society, the protection of natural or ecological values increasingly raises questions on the traditional dominant use by irrigated agriculture. As Allan (2010) identifies, the challenge in many semi-arid countries are decisions on the allocation of the *big* water rather than *small* gains to be made on efficiencies in the public supply sector (see Chapter 13).

In Spain, as a semi-arid country, irrigation is important, where Spain accounts for almost a third of the total irrigated area in the whole of the European Union and its potential irrigated area is almost fully utilised. Irrigation is considered a strategically crucial sector since it consumes around 70% of total water resources and uses 50% of the water kept in Spanish reservoirs in a regular year. Irrigation is key to the agricultural sector since it accounts for 60% of the total agricultural produce (i.e. 13,000 M€ out of an estimated 20,500 M€ and 80% of total farmer exports). Yet it only represents 14% of the agricultural area, although productivity is six times higher than in rain fed agriculture and an income four times higher than in dryland farming.

Increased production, higher incomes, direct and indirect employment and contribution to agricultural Gross Domestic Product (GDP) explain both the inertia and drive for irrigation in Spain. Most of the country is naturally water scarce due to its geographical location and this water scarcity- framed within a hydraulic paradigm- was a problem solved through state intervention, to augment or control water resources, mainly via technological or infrastructural measures. Supply management measures were taken in the 20th century to increase available water through water reservoirs and transfer construction. This supply approach started to be challenged in the 1990s, with the push for so called demand management measures seeking *water efficiency* and *water savings*, where the modernization of agricultural irrigation was seen as the main strategic measure.

The farming sector has also experienced a dramatic transformation, with the co-existence of traditional farming alongside a thriving and dynamic competitive agri-food sector. Thus the sector has become sensitive to a public image as an old fashioned, wasteful and inefficient user of water. This *public image* became particularly poignant in the mid 1990s, when during a prolonged drought, many cities in Southern and Mediterranean Spain and a total of 12 million Spaniards experienced water service interruptions, whilst fields continued to be irrigated. At this point, in the midst of the discussion on the 1993 National Hydrological Plan, the Spanish Parliament asked for a review of irrigation and a National Irrigation Plan. The focus centred on the almost half of the irrigated land, which was still irrigated through traditional gravity fed surface systems, and where technically *water savings* could be achieved through technology-change. Traditional irrigation systems in Spain were portrayed as having low water efficiency (60% on average) (Barbero, 2006) due to substantial water losses in old conveyance networks in extensive flood irrigation systems. Before 2002, 700,000 ha were irrigated by ditches often through a network of concrete channels more than 60 years old, and where large water losses were reported on 400,000 ha. In 2002, 60% of the irrigated areas was still irrigated by flood irrigation, with less than a third of irrigated land having a guaranteed water supply. Sprinkler irrigation was used in only 24% of the irrigated area and only 17% had drip irrigation. After more than seven years of data collection, research and analysis, Royal Decree 329/2002 was enacted in 2002, the starting point for the *National Irrigation Plan – Horizon 2008* (or NIP 2008) to modernise the sector (MAPA, 2001; Barbero, 2006).

3 DEMAND MANAGEMENT AND IRRIGATION MODERNIZATION

The NIP 2008 took a staged approach, with a stated policy objective to modernize 1,134,891 ha by 2008 (i.e. 1/3 of the irrigated area). It covered the period 2002 to 2008, using the framework of river basins and specifying areas to be modernised in terms of hectares per region (Díaz Eimil, 2001). Modernization was based on the lining of old canals and improving the irrigation system and storage facilities, farmer training on good irrigation practices, and on improving water quality and drainage (canals were substituted by tubes in most cases). This Plan represented a shift away from big water infrastructure like reservoirs or water transfers, opting instead for modernization, thought to be cheaper per m^3, while it had the added value of taking into account other social and environmental aspects. The aim was to ensure "that each m^3 had a name and surname" (i.e. the traceability and control of water systems), as stated by the secretary of the General National Irrigators Association in one of the interviews. Farmer organizations and the Federation of Irrigators Communities became active campaigners for modernization, a strong lobby able to glue all the different (often) competing organizations into a common objective: a major investment programme for irrigation modernization. The programme was implemented through the coordination of the Ministry of Agriculture and the Ministry of Environment, which after the 2008 national election were merged into a single Ministry. It was largely executed by State companies who acted as catalysts for State investment, to encapsulate the advantages of the private sector and speed up investment (Díaz Eimil, 2001). The modernization programme relied on three parallel modernization tracks to succeed: i) modernization *upstream* or so called *en alta* or *wholescale*, in e.g. regulation of the main irrigation networks and reservoirs managed by water authorities; ii) *downstream*, *retail distribution* or *en baja* by agricultural agencies (i.e. the lining or substitution of canals); and finally, iii) by *farmers* modernizing their farm at plot level. All these pieces in the puzzle had to fit if the overall targets on efficient water use were to materialize. The NIP 2008 had ambitious targets in terms of projected water savings estimated at 2,100 hm^3 (or 1,850 m^3/ha) [hm^3 = cubic hectometre = million m^3 = 10^6 m^3]. In terms of irrigation technology there has been an evolution from flood irrigation towards drip irrigation. Whereas in 2002 1.3 million hectares were irrigated by gravity, greater than the 1.1 million hectares with drip irrigation, by 2009 the accounted 1.6 million hectares of drip irrigation exceeded those with flood irrigation, which diminished to 1.05 (MARM, 2010). This also indicates that there was not only a conversion on part of the flooding in irrigated fields to drip irrigation, but also an extension of the irrigated land.

A severe drought in 2006 triggered a second Plan, the *Shock Plan for Irrigation Modernization* (or SP 2006), to achieve additional water savings of 1,420 hm^3/year on top of the planned water savings foreseen by the NIP 2008 (Ariza, 2006). Passed as an urgent measure, 2,680 M€ were invested to modernise an initially intended irrigated area of 0.87 million hectares, which rose up to 1.32 million. Therefore the total investment considering both NIP 2008 and SP 2006 was more than 7,000 M€ to generate planned water savings in the order of 3,100 hm^3. According to a study by the Public Policy Evaluation Agency (AEVAL, 2010) on the Segura and the Guadiana basins, the water savings have been of 94 hm^3 in the Guadiana and 65 hm^3 in the Segura. However this has not necessarily translated into reduced withdrawals which would reduce the pressure on the basin or free up water for other uses, as already observed by Molle & Turral (2004) for other cases in different parts of the world. This is due to a number of reasons: first, numbers included in the NIP 2008 and the SP 2006 were savings estimated at plot level (or classical efficiency as described by Lankford, 2012); second, assumptions were made on the type of crop remaining constant; and third and most important, that there would be no increase in the irrigated area.

Zooming into the implementation of the SP 2006, the regions with the largest investment were Andalusia (corresponding largely to the Guadalquivir basin and internal regional basins), Valencia (Júcar basin), Castille-León (Duero basin) and Aragón (Ebro basin) (see Figure 1 and Table 1). Investment however was not necessarily proportional to a corresponding amount in terms of water savings since the type of action under irrigation modernization was varied. However what is also relevant is that an analysis of water savings does not shed light or facilitate debate on the *logic of modernization*. It does not demonstrate a clear explicit *ex ante* decision criteria on where or why money was invested. The case of Andalusia shows that the water savings obtained increase with the intensity of the reforms, which in turn depend on the level of investment per hectare (Corominas, pers. comm.). Thus it would be possible to estimate which areas are more suitable for investment based on the initial efficiency of the irrigation system to identify those that have a higher potential for the most suitable

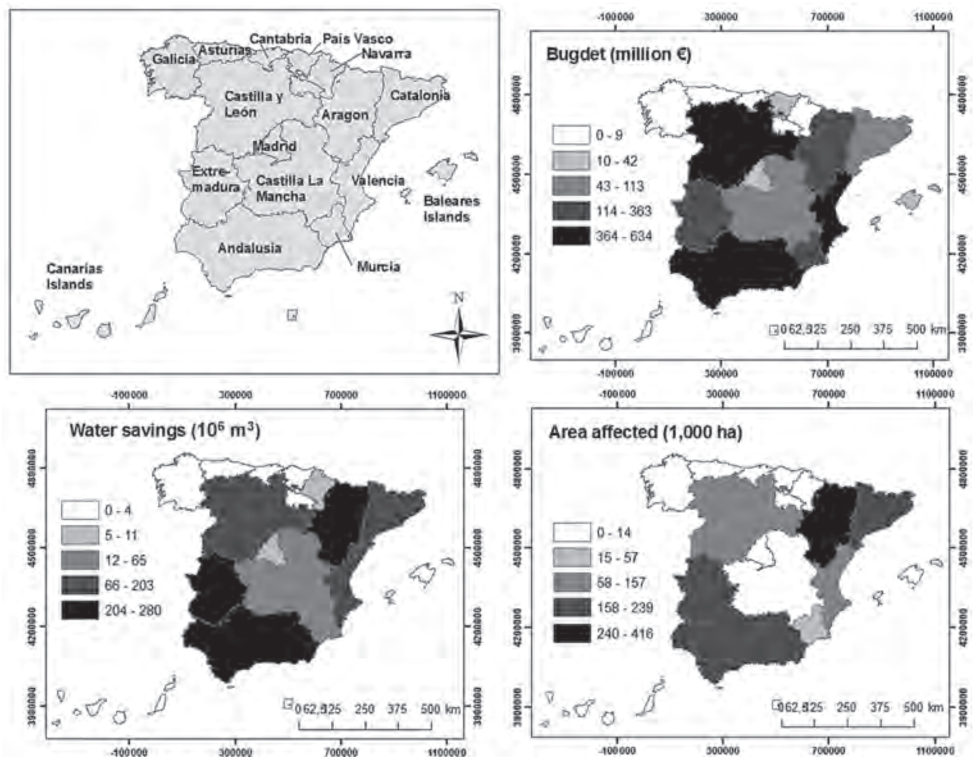

Figure 1 Plan de Choque 2006. (Source: López-Gunn *et al.* (2012), based on official data from MARM).

Table 1 Regional costs per m³, ha and farmer.

Region	*M€/hm³*	*€/ha*	*€/farmer*
Andalusia	2	3,377	53,618
Valencia	3	2,931	8,606
Castille-León	2	3,496	27,739
Aragón	1	871	28,921
Extremadura	1	958	25,265
Murcia	3	3,883	12,788
Catalonia	1	613	6,328
Castille-Mancha	2	6,051	32,177
Basque Ctry.	11	27,775	63,899
Balearic Isl.	16	23,142	53,169
Madrid	4	49,233	–
Cantabria	18	19,770	45,503
Canary Isl.	2	24,725	11,749
Galicia	3	5,132	55,714
Navarre	0	1,518	–
Asturias	20	17,143	40,000
AVERAGE	**5.5**	**11,913**	**33,248**

Source: López-Gunn *et al.* (2012), based on official data from MARM.

modifications to the irrigation infrastructure in order to achieve an increase in water use efficiency. However, the debate still remains on what happens with this *saved water*: whether it remains in the rivers and aquifers or it is put to some additional use (e.g. the irrigation of more land that could not be irrigated before due to technological or water availability limitations) or a change to water intensive crops.

4 THE WATER/FOOD/ENERGY NEXUS IN SPAIN: THE LAW OF UNANTICIPATED CONSEQUENCES

In public policy analysis, often as important as the evaluation of the stated objectives are also the unanticipated consequences. In the case of irrigation modernization, Gleick *et al*. (2011) has raised the importance to look beyond basin efficiency and new water towards basin productivity, and so called *co-benefits*, and a more comprehensive evaluation of what sustainable water management in agriculture means (Fereres & Connor, 2004). One positive unintended consequence (in this case co-benefit) of the modernization programme identified by several interviewees is the reduction in pollution due to the onset of collective fertirrigation, whereby farmers irrigate and apply nutrients at the same time in a more efficient manner. This was stated by the secretary of the Irrigators General National Association, the ex-water director for regional water agency and the technical director of a water authority, which coincided in identifying in having had a clear positive externality in the reduced pollution to streams and aquifers since lower doses of agro-chemicals are applied, and especially because the costs are also reduced by half (e.g. from 300–400 €/ha to 200 €/ha).

A second consequence has been a large investment into the sector (irrigation technology and alternative water supplies like desalination and re-use) which has good prospects in the coming years as an export industry, in competition at the global level for the adjudication of contracts to modernise or strengthen the agricultural sector.

A third unintended consequence of the modernization programme is related to the water-energy nexus (Rodríguez-Díaz *et al*., 2011). In the year 2008, after a process of energy liberalization, and just when the NIP 2008 was coming to an end, the preferential binomial tariffs, the so called tariff *R* were removed (see Chapter 14), with an increase in prices between 50% to 80%. Whereas the cost of water was estimated at 80–100 €/ha, the costs of energy was around 200 to 300 €/ha. That is, the irrigation communities are now paying three times the cost of water in energy costs. This, considering the increase of around 20% on the energy tariff registered in the last four years due to market liberalisation, together with the high loans they had to acquire to face the cost of modernization, has led many of these communities to quite difficult economic situations. According to Head of the Agricultural Public Investment company there has been an average drop in 30% water use (abstraction) at plot level due to modernization, and this lower water use may compensate for the increase in energy prices in those areas with low application efficiencies. The result has been a stronger incentive for farmers to be more efficient in water due to the associated energy costs of using water resources (Corominas, 2009). For example, in the draft Plan that could represent the continuation, or third stage, (MARM, 2010) of Irrigation Modernization energy efficiency is considered as a key priority (IDAE, 2008; Hardy & Garrido, 2010).

A fourth unintended consequence relies in the already observed fact (Ward & Pulido, 2008) that sometimes specific targeted policies to promote water use and irrigation efficiency in agriculture can lead to the opposite effect, the so called Jevons paradox or rebound effect. For instance, the re-use of water savings generated at plot level for the intensification of irrigation or the expansion in irrigated area, ultimately leads to an overall rise in consumptive use (Ward & Pulido, 2008).

Two independent in-depth study is carried out by Cots (2011) and Lecina *et al.* (2010) in the Ebro basin seem to be indicative of these different issues. At least four relevant effects of modernization were observed. First, there may be an overall rise of water consumptions, since the resulting water savings do not compensate for the increased demand brought by the expansion in the irrigated area and the shift to higher value and more water consumptive crops enabled by higher irrigation application efficiencies. Second, there was a reduction in irrigation return flows, which before would have been reused or gone back into the system, thus reducing water supply downstream. Third, there was an increase on energy consumption and energy dependence brought by the generalized mechanization of irrigation. And last, due to modernization there was an increase in water and economic productivities in agriculture, even when constrained by market fluctuations and increasing energy prices. However, when trying to assess whether these patterns are mirrored at the macro-scale for the Spanish NIP 2008 and SP 2006 there is limited aggregated data available to judge on, and the existing data is imprecise and often based on normative judgements. Therefore it reflects a pressing need to make an overall *accounting* and rigorous analysis of the results and impacts of the modernization process, which in line with Gleick *et al.* (2011) also incorporates the concepts of *productivity* and *co-benefits*, particularly if additional large modernization investment is planned for the future.

5 A METHOD TO EVALUATE THE EFFECTS OF MODERNIZATION

It has already been explained how the main justification for modernization plans was the expected water savings, among other associated benefits. These water savings would result in the reduction of water diversion from rivers and aquifers thanks to a better conveyance and application efficiency. However, this approach is overlooking the fact that, often surplus water applied in less efficient system, returns to the basin for a downstream use and is not *lost*. In order to assess the results of modernization, this section proposes a set of indicators which includes all the main aspects (see Table 2).

The first indicator, water quantity, allows for the identification and quantification of the different flows going in and out from the river or the aquifer into the irrigation system through the use of a combination of water accounting methodologies proposed by Molden & Sakthivadivel (1999) and Perry (2007), and the water footprint (WF) as defined by Hoekstra *et al.* (2011). Calculating the WF of the irrigation area *before* and *after* modernization will provide a better estimation of water savings, since this methodology computes only the water that, after use, is not available for further use in the same basin. In the case of agrarian production, the WF includes: i) the evapotranspiration of the crops; ii) the water that flows to *sinks* (the sea or water bodies where it becomes unusable); and iii) the water incorporated in the production (minimal fraction compared to the others). Additionally, beneficial and unproductive consumption can be distinguished, which allows to consider independently evaporation from the soil and plants transpiration.

Table 2 Set of Indicators to evaluate modernization projects.

Indicator	*Aspects to be considered*	*Analytic method or tool*
Water quantity	Types of uses Consumption estimate Water available for other uses	Water accounting method Blue, green water footprint tool Time and location factors
Water quality	Diffuse pollution	Concentration levels of different pollutants in the sinks: nitrates, phosphates, pesticides, etc.
Economic welfare	Productivity. Technological innovation and expertise. Potential technological exports.	Crop (tons/ha). Water productivity (tons/m^3). Side opportunities: Development of technologies and knowledge, business agreements and international cooperation.
Social welfare	Quality of life for farmers. Economic solvency (depending on how funds have been distributed).	Labour hours, RPC. Amortization costs/Economic yield. Intangible personal gain (expertise, technical knowledge, social cooperation and participation, collective power).
Environmental	State of the environment components (aquifers, river flows, soil quality, natural ecosystems maintenance: terrestrial and wetlands).	Evolution of aquifers reserves. Evolution of river flows. Soil quality. State of natural ecosystems.
Energy demands	Evolution of energy demand and dependence. Development of onsite energy sources for self-provision.	Energy demand (kWh/ha). Local energy supply (kWh/ha). Source of energy supply: renewable, thermoelectric, etc. Price of energy (€/ha).

Source: Own elaboration.

Many international research institutions aim to define a general methodology that can be applied worldwide in any basin. The downside, like any generic model made to fit many possible and different cases, is that this might not fit completely for all of them. As an alternative approach Snellen (pers. comm.) sustains that: "many indicators are used by researchers, never by irrigation agencies themselves. An alternative approach is to use *a service approach* [see Dolfing & Snellen, 1999], which also uses performance indicators, but only for checking whether services are delivered as agreed upon. Therefore the main characteristic of these indicators is that these indicators are convenient for the people directly involved: the service providers and the water users". Under this option, the best set of indicators for a certain basin, to fit a specific basin context, is achieved when selected, negotiated and adapted jointly by the water agencies and the water users themselves. This is possibly a more practical approach, difficult to generalise but which might be conducive to achieve the intended (negotiated) overall outcomes[1].

1 For more information on this approach see Dolfing & Snellen (1999).

6 ANALYSIS AND REFLECTIONS ON THREE CASE STUDIES

A sample of three diverse case studies are presented below to highlight the real life complexity from the implementation of modernization projects on the ground, and how these fit within the framework of river basin planning required under both Spanish water law and the EU Water Framework Directive. According to a Deputy Water Comissariat, it should be linked to the planned evaluation on the cost effectiveness of measures.

Case 1 A structural modernization project of groundwater irrigation for a variety of crops in Alicante

A modernization plan of 70 M€ investment affecting 22,200 ha has been implemented. The plan was aimed at reducing irrigation consumption to stop the intensive use of local aquifers, in combination with a hypothetical water transfer from the Júcar River. This transfer which represented an investment of 370 M€ and water reallocation of 6 hm^3 has been delayed for 8 years. The modernization works included: a pressurized pipe system to plot level, 16 storage ponds interconnected through a pipe network and the installation of a remote control system to allow farmers to control the exact timing and amount of irrigation via the internet which allows an accurate water abstractions register. In terms of water savings, it has resulted on a lower reduction of irrigation consumptions than planned (5 hm^3 compared to 20 hm^3 initially planned), however it has ensured the continuity of local irrigated agriculture. This is because modernization has given farmers the flexibility to be able to pump during cheap energy tariffs, cushioning farmers from the rise in energy prices. On the other hand, it has entailed a high level of debt for an average (>60) years old hobby farmer, faced with current low market prices for crops cultivated in the area.

Case 2 A modernization for greenhouse agriculture with high value export crops in Almería

The coast of Almería province (Andalusia) is famous for the process of agricultural intensification based on greenhouses to grow high value vegetables. This however has resulted into a drastic fall on aquifer levels and subsequent marine intrusion. In this area the major part of irrigation water comes from groundwater in a deep confined aquifer. The upper shallow aquifer contains poor water. Because of the deep water table, the pumping costs are high, which has encouraged farmers to adopt drip irrigation to ensure an efficient use of groundwater. Thus, potential new investments is targeted to an already very efficient system, and where investment is geared for system maintenance, but where the potential water savings are low since the application of water is already highly efficient. Investment is justified by the high added value of the crop. The modernization scheme has two main strategies. The first consists on the construction of a new pressurized network to reduce leakage in the water distribution system. It would benefit around 9.000 ha, i.e. almost half the irrigated area. Moreover, this network would interconnect all the different wells, and link them to regulation reservoirs which would allow for a complete monitoring of water characteristics from pumping to distribution. This latter most expensive part of the project is not directly linked with leakage reduction (which is the basis for water savings), it is centred instead on increasing water security through the availability of water (interconnection) and a possibility to pump during the cheapest hours of electricity, which results in financial savings for farmers. The estimated water savings would be around 2.6 hm^3 (i.e. which represents 4.6% of the Water Footprint in the area estimated at 58 hm^3, Dumont *et al*., 2011), for a total budget of more than 27 M€. The second strategy was targeted at generating alternative water resources through two desalination plants and a water treatment plant which provides high quality recycled water (a large investment paid 70% by the government with 20% from European funds and 10% by Irrigation Communities). The plan is therefore focused on the reduction of risk, by increasing reliability for a high value agriculture with a substantial amount of public investment (by the Spanish State and EU) subsidies.

Case 3 The modernization of irrigation canals for rice and cereals in Extremadura

In Extremadura region, the riversides of the Guadiana River basin have traditionally been occupied by irrigated fields where surface irrigation of cereals and rice was and remains the main practice (44.6%). A slight trend has been observed towards drip irrigation. However, the most important modernization works were oriented towards improving the state and efficiency of the irrigation network, and especially of irrigation canals. The first project consisted on the substitution of the old pipe system for a new impermeable concrete one and the installation of flow meters reaching to plot level. The second project entailed the installation of an automated telecontrol system which allows for the programming and monitoring of precise irrigation programs via internet or mobile phone, while flow and water quality measurements are periodically taken. The investment required by these two projects accounted for 34 M€ with estimated 129.6 hm^3 water savings. These estimations though, have been made by the calculations on the theoretical improved efficiencies. These however have not yet been contrasted with figures based on real measurements. It does not mean it is not possible since the projects include the installation of flow meters which allow for a close tracking of water consumption.

Source: Own elaboration on the basis of fieldwork and expert interviews.

Table 3 Main characteristics of the three study cases.

	General characteristics		*Farmer characteristics*			*Modernization plan*		
Case	*Main crops*	*% active pop.*	*Age*	*Type*	*Economic yield (€/ha)*	*Overall cost (M€)*	*Theoretical savings (hm^3)*	*Real savings (hm^3)*
Alicante	Vineyard, olive, almonds, vegetables	6–10	>60	High % hobby farmer	1,500	70	20	5
Almería	Paprika, watermelon, melon, aubergine	50	40	High % commercial farmer	26,470	27	2.6	Lost due to higher ETP
Guadiana	Cereals, rice, forage crops, olives	13.8	30–40	Commercial farmer	1,290	34	129.6	Not measured

Source: Own elaboration from SEIASA (2010).

At the micro or operational level these specific cases highlight the complexity of the modernization process, where the implementation of similar patterns of investment in different areas gives way to very different realities, especially in the social and economic spheres e.g. the capacity to cope with the investment and pay back costs is not the same for the average 60 year old farmer with a middle rent than for a high income 40 year old business farmers. These differences were probably not considered *a priori* to evaluate the extent to which in some areas these large public and private investments were justified considering a large number of potential consequences or indeed to set some criteria beforehand to decide on the destination and distribution of funds. Applying the theory of the policy cycle to the modernization process, the issue on how to invest scarce resources of *time* and *money*, and how effective results are according to the original aims (achievement of objectives or unexpected consequences), is one of the uncertainties a government has to cope with. However, the only way to tackle this uncertainty relies on the elaboration of a systematic planning process which includes three main steps: a characterization and pre-evaluation of the initial situation, a close monitoring programme to keep track of the evolution, and an *ex post* evaluation of the final results (Figure 2). In this sense, it is important to distinguish the *Agenda de Regadíos* 2015 of Andalusia (Junta de Andalucía, 2010a; 2010b), which includes a thorough analysis of modernization projects and presents a coherent and well conceived plan for tracking the effectiveness of the plan.

The evaluation step is designed to identify possible deviations or changes on the initial conditions to then readapt policies, or learn from them. The lack of this step is actually the most important gap in the NIP 2008, which had three important consequences:

i First, well justified criticisms on the realization of water savings can eclipse some other important positive aspects and successes achieved, such as the implantation of an accurate measurement system which keeps detailed track of the

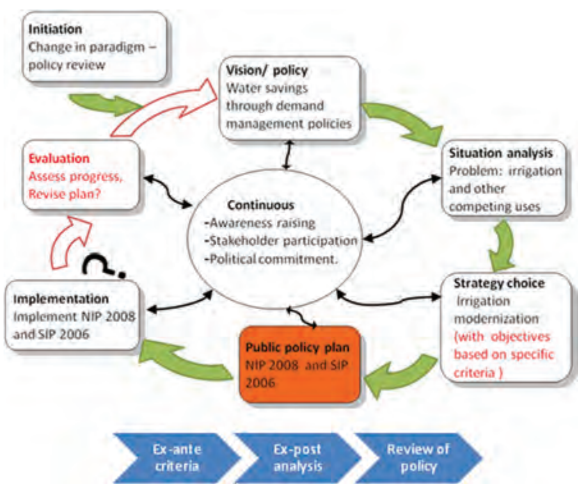

Figure 2 The incomplete policy cycle of irrigation modernization. (Source: Own elaboration).

water consumptions in important basins. This represents a huge advance in GIS characterization and in irrigation technologies and important increases on agricultural productivity and farmer's quality of life. It is a very powerful tool for water planning giving access to better or more accurate data on actual use.

ii Second, well intentioned initiatives can fail if the appropriate means and strategies are not implemented, and there are (expensive?) missed lessons to learn from the implementation of these two major public investment programmes: there were good intentions to make plans together with the Irrigation Communities. However, the eagerness for speed and execution of works by the State building companies, in common with other infrastructure projects, has led in some cases to the delivery of rushed plans and the need to repeat some works and consequently higher investments than initially estimated.

iii And third, important failures or counterproductive actions if not detected could be repeated later on, or with alternative policy paths not being considered. This is especially relevant considering that a third phase of the Irrigation Modernization Plan Horizon 2015 is planned (MARM, 2010) with important public investments. In this context lesson drawing on the approach pursued focused on technical (irrigation) water use efficiency, by eliminating any unproductive loss and generating or importing new water resources. However, to adjust supply to irrigation demands it is important to also consider whether the new plan could instead look for other strategies like more sustainable and appropriate crop patterns or activities, such as solar energy, and adapt to the real existing and available resources.

7 CONCLUSIONS

In the 1990s wasting water in irrigation was bad for the public image of agriculture and for irrigation, when in the middle of a drought cities experienced restrictions, while fields continued to be irrigated. Ten years later in the mid-2000, during another prolonged and severe drought there was no need for the introduction of restrictions. According to the representative of the irrigation associations of Spain, this is both tribute and evidence on the success of the irrigation modernization programme. However, other voices are still engaging in the debate on the future and logic of irrigation and a large public investment in modernization. Some sectors demand that water flows again in rivers and is preserved for other sectors, as required in a modern society, to reduce the pressure on aquatic systems. In a modern country where only 4% of the population is directly employed in agriculture (see Chapter 6) and a great portion of it is aged, there is a new dichotomy since this co-exists with a highly dynamic, entrepreneurial agri-business sector thriving despite or because of the current economic crisis. This dichotomy forces a re-think on the logic for irrigation in Spain as a mature water economy, and where the Spain of the 21st century bears little resemblance to the Spain at the end of the 19th century. It also brings out the uncertainty on the maintenance of a stable primary sector which ensures food security in the future, not only in Spain but in the whole of Europe, given the ageing process of rural population and the crucial role of the younger generations to take over.

One of the upcoming questions in Spain after a major public investment programme of around 7,000 M€ over the last ten years into irrigation modernization (like other major programmes undertaken on roads, or high speed trains), is to establish the logic and parameters for returns on this large investment in irrigation modernization. This is particularly pertinent in the present situation, when public investment should be thoughtfully re-assessed and with a third phase of modernization plans on the way. As analysed before in this chapter, irrigation technical efficiency is neither necessarily equivalent to water savings, nor the only means to achieve them. This chapter argues that a focus on water conservation would provide a clearer end goal for policy, and open the door to a wider range of measures on water management to be combined in the ideal policy mix to fit different circumstances, i.e.: water tariffs (OECD, 2010), water quotas, water markets, self-regulation, conditional water licenses and crop switching to less water consumptive crops (as already implemented in the *Agenda de Regadíos de Andalucía, Horizonte 2015*). In this context, the use of a complete variety of indicators and water accounting methods will also have to consider other aspects such as farmer welfare and water productivity to shed light, at national and regional level, on the social, economic, hydrological and environmental viability of future irrigation modernization processes. Rural development is no longer synonymous with agriculture, but rather seek a more diversified and integrated economic balance between sectors (e.g. renewable energy and solar farms, rural tourism, etc.).

After all, it is ironic that with irrigated agriculture caught at a crossroads between two external policies (the reform of the Common Agricultural Policy and the compliance with the EU Water Framework Directive) and despite the lack of firm conclusions about the magnitude of real water savings, it is the unexpected impact of the parallel policy of energy liberalisation that has opened a new space for decision making in Spain on the overall efficiency gains to be made in resource use (water and energy).

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