


Smart Water Governance in Moroccan Agriculture: New Science and Policy Collaboration and Partnership

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Abstract

The emergence of concepts like integrated water resources management and river basin management should be seen in the light of the governance transformation. The full potential of the governance transformation for improved management of water resources and services is yet to be fully realized. The general objective of this research was set to contribute to achieving SDGs related to water (SDG6), gender equality (SDG5), livelihoods and nutrition (SDG2), through a better decision making and giving more voice to water users in agricultural water governance. One of the most important activities is the analytical review of the current situation and existing institutions in both research and policy development and implementation in agricultural water. So the objective of the study was the establishment of the appropriate mechanisms for bridging research and policy in the case of water governance in agriculture. The research approach is based on interviews and face to face discussion. The main output of this activity is that organizations are working in silos with no or limited coordination between water and agriculture. Parallel structures in research and policy with no institutional pass ways, the weak governance has implications on sustainability of land and water, water use efficiency and water productivity, economic return for investments, that challenges food and water security set SDGs, despite the existing policies aiming at involving farmers and water users organizations in local decision making.

Keywords

Water, Irrigation, Governance, Stakeholder, Advice

1. Introduction and Problem Justification

Climate change is the most complex challenge facing many countries in the 21st century, and water use and management are becoming crucial issues. In Morocco, MAGICC model (Hulme et al., 2000), centered on the North African region predicts a warming trend by about 1°C and disturbance regimes rainfall with a downward trend of 5% to 10%, between 2000 and 2020 period. In addition to favorable ecosystems, arid and semi-arid regions are more vulnerable to climate change. In Morocco, population growth, industry, tourism and rainfall variability (quantity and distribution) are the main factors affecting water demand and make pressure on water resources. The situation is becoming more complex by the extension of irrigated area and the involvement of many actors for water management and governance.

Water management in Morocco, as in the MENA region, is linked to the management of natural resources such as forest, land, etc., and must meet the needs of the main uses: agriculture, industry and domestic uses. The geographical situation of Morocco between Atlantic Ocean and Mediterranean Sea, Morocco is relatively well supplied on rain compared to other countries in North Africa. In addition, mountain ranges, which cover a large part of the national territory, act as reservoirs. Average precipitation is estimated at about 150 billion cubic meters (m³) per year in general. However, two constraints must be noted, namely the variability of precipitation over time and space. Morocco has always had dry years, but their frequency and severity have increased dramatically since the early 1980s. Over the last 16 years, nine dry years have been recorded (56%), while during the first half of the century, there is only one drought every ten years. The spatial distribution of rainfall in Morocco is characterized by declining gradients from North to South and from West to East. Some regions receive 600 to 700 millimeters (mm) per year, while others receive less than 100 mm.

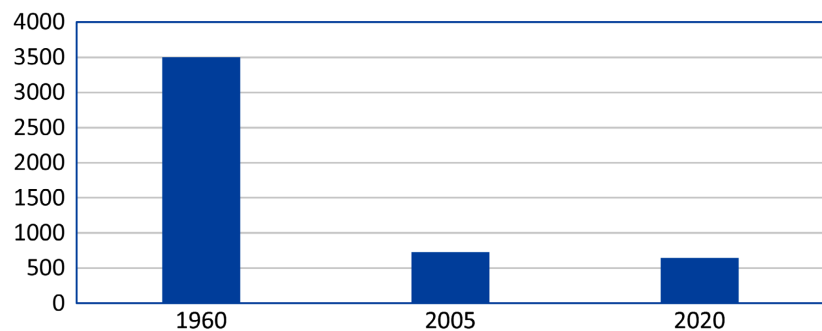
To adapt 2030 United Nation Agenda including its 17 SDGs to its context, Morocco has initiated different actions, which are part of the National Strategy for Sustainable Development (NSSD). The main objective of NSSD is to ensure coherence and synergy between policies, programs and sector plans, including food security and agriculture. To achieve the objective guaranteeing water and food security, Morocco has launched different projects such as; Policy of dams, water laws (10/95 law followed by 36/15), the creation of the Higher Council for Water and Climate, desalination, the Green Morocco Plan with its two pillars (the first focuses on modernization and competitiveness while the second on social support), promoting agricultural research, and supporting farming system reconversion, promoting water saving technologies, introducing new concepts for agricultural advisory and adapting agricultural policy interventions to other sectors such as energy, environment and marketing.

Up to FAO/Government of Morocco preliminary diagnosis of the challenges

of agricultural sustainability (FAO-SFA approach)¹, water emerged as one of the major challenges of sustainability for the agriculture in the future. The acuity of problems vary according to the regions, conflicts of use, risks of shortage, pollution, overuses of the groundwater and risk of shortage aggravated in a context of climate change (variability and quantity). Several causes are mentioned such as; accelerated development of water demand (all sectors), excessive water consumption in relation to available resources, and intensification of agriculture with new areas irrigated by pumping, urban, coastal/tourist and industrial development, water pollution and quality degradation. Per capita consumption is declining (**Figure 1**) indicating that urgent actions that must be taken by government, civil society and private sector.

These issues are not new, as evidenced by the numerous programs, strategies and projects aiming to solving the problems. In the NSSD pointed out in 2009 that the risk associated with water is reinforced and the deficit of 5 billion m³ by 2030 is a reality and interventions must be addressed. The same study highlights the weaknesses of water governance and the limits of the coordination of public water policies. The main problem seems to be the non-systemic treatment of this problem between actors and the lack of coordination between sectors' interests. According to the diagnosis, this problem results in inconsistencies between the instruments of implementation of different sector policies that lead to a negative effect of these policies on the management and use of water, thus contributing to the inefficient use of water resources.

In the context of sustainable agriculture and the implementation of the 2030 sustainable development objectives, the coherence on water policies among sectors is an urgent necessity. This coherence is justified by the growing number of interconnections between environmental, economic, agriculture and social policies. Indeed, they are targeting the satisfaction of a large number of different objectives and a large number of different actors and interest groups. In this situation, policies will be less effective with no impacts. Even for water policies, we



Source: Kingdom of Morocco: Sustainable development in Morocco (2012).

Figure 1. Trend in water availability m³/capita in Morocco.

¹FAO and the Moroccan government jointly conducted a diagnosis of the challenges of agricultural sustainability in Morocco, based on the FAO SFA approach, including his first four principles. This diagnosis identified priority issues for the sustainability of agriculture in Morocco. The diagnosis was conducted in 2015-2016 cropping year.

have conventional and non-conventional water and specificities in term of uses, quality control and support should be considered.

Given that this research is a logical continuation of the research on irrigation and water management program of INRA and other NARS² institutions, the study aims to present an overview on water governance and water management in the context of water scarcity and climate change. Improving dialogue and collaboration between researchers and actors is an objective of the public policy that can be achieved if scientific evidence is considered and adopted by policy makers, water users, administrations and all water actors in implementing interventions. The concept of water governance platform is used in the case of Tadla large irrigation scheme according to the vulnerability of the production system to water stress and the importance of actors, and the opportunity to value scientific research output on irrigation and water use efficiency (Karrou et al., 2011).

2. Research Methodology

The methodology adopted was based on three major components: a literature review on water and agricultural policies, existing socioeconomic and biophysics data on production systems and irrigation, water organizations, and on-farm research experiments. A combination of literature review and in-depth analysis (both published, secondary data, unpublished reports studies...) of current status research on water and land management with a focus on policies strength and governance gaps and weaknesses. The data was combined with data generated in previous surveys that allowed stakeholders profiling that were updated.

The thorough review served as to guide the key structuring elements of the dialogue. Later series of formal and informal meetings with different stakeholders (one on one), followed by dialogue with all stakeholders together. The participatory multi-stakeholder workshops conducted at the basin level and research institute were to develop an understanding of the governance concept and try to develop comprehensive information on stakeholders profile, water management problems and collaboration options.

The preparation of both workshops was based on the bibliography and the presentation of the scientific evidence on water allocation, water economic productivity, supplemental irrigation research conducted in the basin and that can support policy issues or water governance practices.

A validation process of the dialogue key outcomes was carried out to ensure the consistency and implementation of the project results. Then a final wind up workshop to hand over the leadership of the governance structure established to partners to ensure its sustainability by the Basin Agency implementing the MoU and confirmation of commitments of the agency and partners including financial sustainability.

Finally, it's important to notice that outputs of different studies on technical

²National Agricultural Research System.

efficiency and irrigation system conducted by INRA and ICARDA in Tadla were shared with actors.

3. Project Outputs

Stabilization of the macro-economy and economic development were prioritized in the strategy of developing water sector in Morocco. Social issues such as poverty reduction, education and regional gap, etc. were targeted by policy makers. Water scarcity restricts agricultural production and affects farmer's income. In agriculture more efforts are needed to improve water policy in order to improve production efficiency and contribute to food security. To better design water governance and management it's important to understand water policy coherence and how Morocco has adapted this policy to the economic and climate contexts.

3.1. Policy Incoherence and Water Management in Morocco

Morocco is characterized by low rainfall and high precipitations amount fluctuations. Water resources are seriously threatened by the decrease of water available and the deterioration of its quality and the situation will be more critical due to climate change. As the *EESC (2014)*³ points out, the availability of water resources is strongly influenced, in particular by the low level of water amount (22 billion m³/year, 82% of which are surface water and 18% is underground reserves) and their depletion under the effect of climate change, increasing floods, soil erosion (23 million hectares affected) and the reduction of dam storage capacity following filtration (75 million m³/year with a cumulative loss estimated at 1750 million m³ out of a total storage capacity of 17.5 billion m³). According to recent official statistics, there is a clear decrease trend of water availability per capita. The availability of water has declined from 1700 m³ per person in sixties to 700 m³ in 2017. Correlated to the demographic, economic, urban and industrial growth of the Moroccan regions, it appears that water deficit will increase to 5 billion cubic meters a year in 2030. Consequently, the water availability is expected to decrease to 500 and 350 cubic m³/capita/year in 2030 and 350 in 2050 (*Taheripour et al., 2020*)⁴.

Today, Morocco and despite the potential of dams widely exploited, the water supply has not met the needs of the agricultural sector. Thus, the agricultural water policy envisaged exploiting all available water resources and even unconventional waters. This is not a new alternative, as several regions have already started using wastewater to irrigate cereals, mint, fodder and many other crops. Following this shift, this is both necessary to value the huge amounts of water already used but also that can cause harm to the ecosystem as a whole. Despite

³Conseil Economique, Social et Environnemental (EESC) 2014. La gouvernance par la gestion intégrée des ressources en eaux au Maroc: Levier fondamental de développement durable. Auto-saisine no. 15.

⁴Taheripour, Farzad; Tyner, Wallace E.; Haqiqi, Iman; Sajedinia, Ehsanreza. 2020. Water Scarcity in Morocco: Analysis of Key Water Challenges. World Bank, Washington, DC. © World Bank.

the environmental and health risks related to the use of untreated wastewater, some regions of Morocco had invested in its use while respecting certain measures regarding the choice of crops.

In 2015 the Ministry in charge of water gave the outline of the National Plan of Water Saving (NPWS). It was pointed out that the NPWS is not only aimed at saving water and increasing supply, but also at the need to use other type of water, especially wastewater. The NPWS offers new options for exploring other water resources according to new regulations and restrictions that was implemented. However, all plan and policy measures were not able to solve the use and reuse of water in agriculture. More efforts are needed to optimize the use of water in agriculture.

To consolidate the old water law 10 - 95, parliament has approved the new Law 36 - 15 in November 2015. The 36 - 15 law comprises 163 articles and clustered into 12 chapters. Issues such the use and exploitation of the water, the valuation and use of non-conventional water; the administration of water, water planning and preservation. Groundwater contract was introduced to control more water. This new law is developed to reinforce water policies and strategies developed last 20 years.

3.2. Water Policy

In such water context, the concept of water saving was adopted by public authorities. In fact, it is a question of safeguarding the productive potential of the irrigated perimeters which have always constituted the main sector that improve farm income and creates jobs. Water saving strategy requires not only the adoption of the most water-efficient irrigation techniques but also the development of production systems that make the best use of limited water resources. Indeed, the real source of water saving in the context of water stress is productivity improvement and water valuation. In other words, it is about producing more wealth (agricultural production, added value, jobs, etc.) per m³ of water. So the national plan for water saving introduced several innovations and approaches to promote water saving and its valorization:

- The modernization of the irrigation system by introducing localized irrigation. Financial incentives were allocated to farmers adopting drip irrigation system. Up to now only 34900 ha are concerned, which represent only 5% of large scale irrigated area.
- The promotion of a triple mutation and transformation of irrigated agriculture: a modernization of irrigation systems by adopting the localized irrigation system, a transformation of production systems towards systems with higher added value and modernization of water management and governance instruments by involving all stakeholders in water use and groundwater resources management.
- In order to ensure farmers' support in the process of collective modernization, WSNP introduced the partnership and participative approach. This ap-

proach was based on the analysis of the social water demand and the constraints to the adoption of water-saving technologies and the valuation of water.

- The modernization of irrigated agriculture will now be conceived as part of a global vision that integrates agricultural research and the promotion of the valorization of the agricultural productions. This strategy affects all levels of the problem and requires economic, technical and socio-institutional alternatives.

In the past, water policy has long focused on supply, including increased efforts and investments to ensure the mobilization of sufficient resources (the so-called “dam policy” and one million hectares irrigated in the 60 s). The adoption of Law 10 - 95 fundamentally reoriented the management of the resource and supported the decentralization of water management by creating watershed Hydraulic Basin Agencies (HBA) at catchment scale and the establishment of Agricultural Water User Associations (AWUA) at the local level.

The law on water was revised in 2015 in order to ensure better control of water demand. The new law 36/15 stresses the basics of water management which are: the public ownership of water, the right of all citizens to access water, the right to a clean environment, the water management in accordance to the good governance practices, taking into account the participation and the consultation with different actors and the integrated and decentralized of water resources management, the protection of environment and the development of sustainable management, as well as the adoption of gender approach in water resources management.

The new law also provides the establishment of watershed advisory councils in order to study and capture their opinions on the integrated water management action plan, the establishments of a legal framework for seawater desalination, and oblige cities to develop their own master plans for water treatment taking into account seawater and the need to use wastewater. The law also provides new regulations for digging wells, the establishment of a coherent legal framework for flood prevention and protection, and the development of water-related computer systems at the basin and national levels, allowing a systematic monitoring water use and management. The law targets the simplification of procedures allowing the use of water in the public domain. It also institutionalizes groundwater contracts as an important instrument of rebalancing groundwater levels. All of these measures have led to the awareness about the water sector and improve its governance.

The main problem is the implementation the laws and the plans. Most of water basins have no expertise and less human resources to be able to apply and monitor plans. In the field, water management is not AWUA’s concern. They have developed appropriate water organizations but their interventions remain limited and do not have more power to contribute to water management (water allocation agenda, water tariffs and equipment maintenance). Water governance

is still surfing from the institutional fragmentation and the multiplicity of actors. More efforts are needed to simplify procedures, empower users and to make research results accessible to different actors to better guide water governance in agriculture.

3.3. Water Management: Institutional Constraints

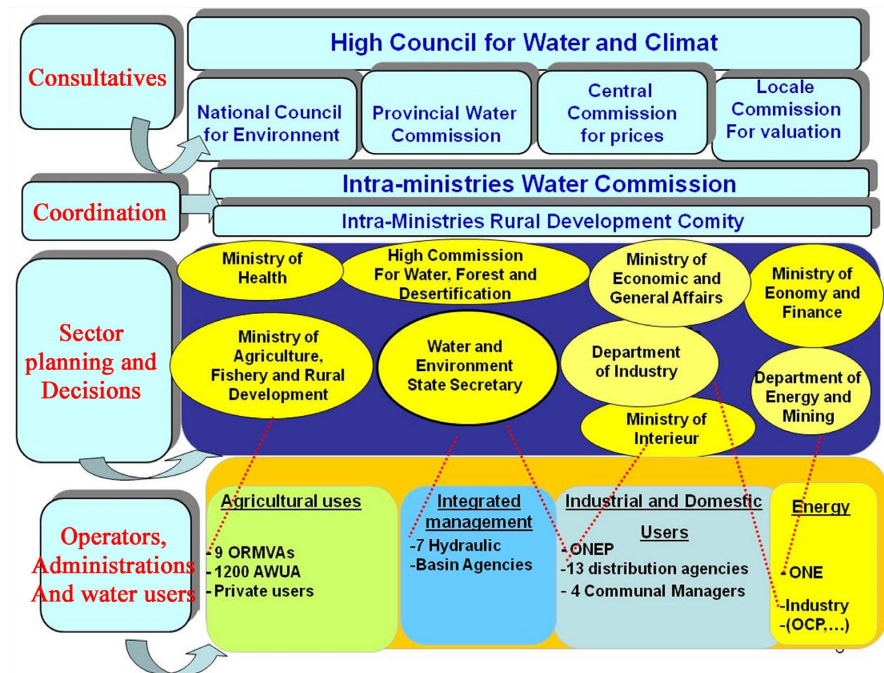
Water policy is a set of transverse policy measures that involves several actors, which requires a job description and formatting of the content of the intervention of each actor. So the organization of the water sector aims to implement an integrated management of water resources taking into account the quantitative and qualitative aspects, as well as a better coordination of stakeholders. However, up to now, despite the existence of a strategic steering and regulatory body, which is the Higher Council for Water and Climate (CSEC), there is still no logical framework for a precise outputs and objectives to be achieved.

Water production and management are provided by several organizations that have specific skills in water management cycle and according to water uses: consultative bodies, ministerial departments, public institutions and private operators, local communities, local authorities and associations. Thus water management is characterized by the multiplicity of stakeholders, the complexity of the organization and skills and the overlapping of their attributions.

Water policies are developed by the Ministry of Environment, Ministry of Finance, Ministry of Interior, Ministry of Agriculture and Water State Secretary. Now, the General Council of Water is becoming a powerful unit for developing water strategies. More than 86% of water is under the control of Ministry of Agriculture through regional administrations (ORMVA)⁵ but still water pricing involves the Ministry of Finance and other ministries. Stabilization of the macro-economy and economic development were prioritized in the strategy of developing water sector in Morocco. Up to **Figure 2**, policies are defined at the top level by ministries. Water uses are under the control of local administrations that are not, in general, involved in water policies.

In theory participatory irrigation management generally keeps these boundaries of responsibility unchanged but look for the intensification of the role and the contribution of farmers in some areas: farmers will be asked to establish Water User Groups (WUG), or Water User Associations (AWUA), at the tertiary level with the expectation that this would help them better manage the distribution of water, carry out maintenance tasks collectively, and sometimes collect water fees for the agency (although the fees collected can be also kept locally and partly used by the AWUA). Other expected tasks can be assigned to water association, such as negotiating with the water provider, better communication, collecting information on planned or actual cropping patterns. As a result the degree of participation may vary considerably, in both extent and intensity, and what comes under the institution.

⁵Office Régional de Mise en Valeur.



Source: Belghiti M'Hamed, 2008.

Figure 2. Water sector organization in Morocco.

The concept of Irrigation Management Transfer, or IMT, as defined by Garces-Restrepo et al. (2007)⁶, refers to the process that seeks the transfer of responsibilities and power from the controlling government agencies managing irrigation systems (under the public sector) into the hands of an association or local institution (NGOs), such as AWUAs. Usually, these are established as recipients of the transfer of management.

There is a difference between participatory irrigation management and irrigation management transfer. The case of AWUAs can be related to the establishment procedure and the way of attributions and roles are defined by the government agency. These attributions generally relate to decision-making power.

If we can qualify AWUAs as a typical form of IMT, water policy should reinforce the effective transfer, not only tasks and activities, but also a large part of decision-making power and/or enhance the cross accountability between the ORMVA and users. In Morocco, the ORMVA keeps full control of water allocated to agriculture. The full transfer of power to AWUAs will improve the involvement in the decision-making in the three key areas outlined above and empower water organizations to control and rationalize the use of water among farmers.

Social scientists have well defined the forms of farmers' participation to water management and they stress on the distinction between instrumental and transformative participation. Participation can be stratified from a range of categories, from manipulation to citizen control. When the variety of definitions of

⁶Garces-Restrepo Carlos et al., 2007, *Irrigation Management Transfer. Worldwide Efforts and Results*, FAO Water Report n°32.

‘community participation’ are applied, this can lead to a wide variation of expected impact and outcomes, particularly if we consider social and intellectual status of community members⁷. Taking into account these theoretical and social considerations the following question arises; are water users’ associations able to manage 100% of the irrigation water (equipment, allocation and maintenance). Water tariffs are set by different ministries and actors at the macroeconomic level and farmers are represented. Still this issue is not under the control of users but HBA and ORMVA are open to farmer’s contribution.

Actually, the context is favorable to innovative options that can improve water governance. With the new empowerment of water basin by 36/15 Law, science and policy bridge should be more reinforced and joint research/development programs must be developed. The National Agricultural Research System led by INRA has conducted with different research programs on water management and irrigation system alternatives. Appropriate options are available to be adapted and adopted by users. The multi-stakeholder memorandum for developing a water governance platform can be considered as an innovation that can benefit both research and development agencies from research and sustain collaboration with water users association.

3.4. Water Governance Perception

According to the interviews, water governance perception is defined by the rules and the power of each actor⁸. Even farmers with high power, interest and a strong legal status AWUAs are not fully involved in water ratification and water allocation. They are members of the board of HBA and the Federation of AWUA is represented in the water council but more efforts are needed to empower more AWUA and involve the Federation in all aspects that concern water use efficiency. The different perceptions are reported in **Boxes 1-4**.

4. Conclusion and Challenges

The public sector invests in research and irrigation infrastructure to improve agricultural sector performances and contributes to food security. Many agricultural production systems, including irrigated agriculture, perform poorly. In many areas, lack of policies, insufficient awareness and poor management have led to dramatic misuse and misallocation of water in agriculture, resulting into land degradation at regional scale. So it’s an urgent need to deal with the issues of local and regional management of water resources within a comprehensive framework, in which appropriate policies can be formulated through a participatory and integrated approach and implemented.

Technologies of improved management of scarce water resources are available.

⁷Larry A. Kroutil and Eugenia Eng (1989): Conceptualizing and assessing potential for community participation: a planning method. Health Education Research Theory and Practice. Vol. 4 n°3, pp. 305-319.

⁸Chevalier J. and Bukles D. (2008). SAS² A guide to collaborative inquiry and social engagement. International Development Research Centre/SAG Publications India Pvt Ltd. PP. 316

Box 1. Green Morocco Plan (GMP) and water management.

In April 2008 Morocco adopted a new strategy for the development of agriculture called the “Green Morocco Plan”. This strategy, which aims to make agriculture a driver of the growth of the national economy, is articulated around 2 pillars:

- The development of modern agriculture with high added value, and
- The upgrading of a social and solidarity-based agriculture for the poverty alleviation.

To cope with the growing scarcity of water resources, the GMP and the National Water Sector Strategy (NWSS) have adopted a National Program for the Water Economy in Irrigation (PNEEI) which is part of the transverse component of the GMP map. Even water saving in the irrigation sector in Morocco is an old objective, this program has the particularity of being prepared in a new political, environmental and socioeconomic context characterized by:

- In terms of water supply: An increasingly restrictive water context characterized by climate change, over users of water resources and water table degradation,
- - In terms of water demand: An increase of water demand and competition over conventional water resources

Clearly, irrigated agriculture is the sector most affected by water restrictions because of the of the unpredictable increase in the demand for drinking water (which benefits from the priority in terms of allocation in a situation of scarcity) and the reduction in water supply to dams on the groundwater. In other words, all these restrictions have affected irrigated agriculture with all the range of negative impacts on crop productivity, crop intensification, and water productivity. Other impacts on production and on farm income, the reduction of employment opportunities in rural areas, the acceleration of the exodus to cities are expected. So this political will implies new approaches embodied in the framework of the PNEEI by the collective modernization projects of irrigation systems in the perimeters of large scale irrigation. It is for the State to act by:

- Financial incentives for projects aiming water saving. Up to now only 34,900 ha are converted to drip irrigation (5% of the areas managed by the State).
- The creation of hydraulic and development conditions favorable to the conversion to water saving irrigation techniques and the overall modernization of production systems.

It's not a matter of modernizing the irrigation systems at the risk of disempowering the farmers who are the key players in this process. The solutions to be sought are probably social as well as economic and technical, in particular through a voluntary change in which the public authorities act as a catalyst to help farmers modernize their production systems and guarantee their income while enhancing water resources use sustainability. It's a question of stimulating a triple mutation and transformation of irrigated agriculture by introducing drip irrigation associated with other alternatives. A transformation of production systems towards systems with higher added value and modernization of water management and governance instruments to increased stakeholder accountability for irrigation systems, irrigation management and groundwater resources.

NWSS aims to convert to localized irrigation of nearly 550,000 ha in 15 years including:

- Large scale hydraulic schemes (GH): within 395,090 ha a total area of 218,000 ha will be covered. In these irrigation perimeters, the objective is to accelerate the modernization of collective irrigation systems;
- Private irrigation zones (IP): 160,000 ha corresponding to 50% of the area irrigated by flooding. In these areas, the plan aims to develop appropriate mechanism such as financial, incentive and institutional, that can contribute to the conversion to drip irrigation. The area converted to the new irrigation system will reach 700,000 ha.

The program is organized around five components: 1) Collective modernizations of large hydraulic perimeters (including upgrading irrigation networks); 2) Private modernizations; 3) Valuation of agricultural productions (market and prices); 4) Strengthening technical advice; and 5) Other measures such as aid procedures simplification and the organization of the institutions and actors involved in the sector.

The expected impacts of the NWSS are water saving about 20% to 50% by reducing water losses, reduce the vulnerability of irrigated agriculture to climate change through better control of water resources, the increase of water productivity from 10 to 100% depending on the crop; the increase in water valuation by nearly 114% (5.12 Dh/m³ instead of 2 Dh/m³); the increase of agricultural income; the increase of national agricultural production and the contribution to the commercial balance and the maintenance and creation of new jobs.

What is important to notice in this new strategy of water use is that the ministry of agriculture perceives water governance through the improvement of irrigation system and all associated technologies, institutions and policy options. It's clear that more efforts are needed to value science and social knowledge.

Source: Ministry of Agriculture, 2008.

Box 2. Agricultural Water Users Association (AWUA) perception of water governance.

According to the Moroccan legislation, the AWUA has financial resources (membership fees, annual and permanent contributions) to be operational and finance its activities. It benefits from tax benefits in the form of total and permanent exemption from all taxes. It can benefit from state subsidies and special bank treatment in borrowing funds. Once established, the AWUA signs an agreement with the administration concerning the planning of water resources, planning and equipment maintenance of the perimeter of irrigation. In the agreement the area and perimeter's boundaries of the AWUA are defined, the plan of work, the investment strategy, the financial contribution of users, the maintenance and upkeep of the hydraulic network are well defined.

The main objective of creating AWUA is to develop co-sharing practices among users, ORMVAs and DPAs or the transfer all water management activities to organized farmers, usually illiterate but with irrigation expertise. This new option must be the least damaging the global objective and interest of the ministry of agriculture, and the most profitable to the associations, and therefore to all social categories of farmers themselves. It is also necessary to determine what is the level of AWUA responsibility (head office, network management, association, enterprise, et..) most adapted to their skills, education level and functions or activities. The sharing of responsibilities may be perceived by associations as a poisoned gift and by administrators as a disposal of their usual prerogatives. On the other hand, farmers risk seeing their traditional needs (sustainability of water service, extension, supply of inputs, etc.) not satisfied by the administration, and for others not yet supported by the associations.

So far the associations have been able to play an important role of liaison between water users and the administration. They have little involvement in the management of the network but they have had representation on the Board of Directors of the Hydraulic Basin Agency and even for others and they are members of the High Water and Environment Council. However, all these advances do not give them the power to negotiate water allocation among sectors, the irrigation schedule and water pricing. Up to AWUA these aspects are most important problems that a smart water governance can contribute with. Through the MOU, the AWUA is looking for improving its participation in defending water users' opinions regarding the tree mentioned issues.

Source: Stakeholder interviews conducted in 2018 in Tadla region.

Box 3. ORMVAT perception of water governance.

Within the framework of the hydraulic development model adopted in Morocco, three main actors intervene in the planning, development and management of water resources. In addition to the Administration which intervenes, as promoter and regulator in the realization of hydrologic installations and their management, the Regional Offices of Agriculture (ORMVA) intervene as organisms in charge of the development and the management of irrigation systems and promotion of agricultural development, and farmers intervene as users of water at the farm level and recently the Basin Agencies are entrusted with very broad integrated water management at the watershed scale.

Since 1966, public authorities have opted for decentralizing water management through the creation of autonomous structures integrating all the services needed for the development of large scale irrigation system. Created in a perspective of overall development in areas with high agricultural potential where water was then limiting factor of development, the role of the ORMVA consists mainly of:

- Ensure the realization of hydraulic perimeters on behalf of the State;
- Ensure the operation and maintenance of equipment to ensure a permanent and efficient water service;
- Provide tailored support to farmers for agricultural development;
- Recover irrigation water charges and carry out water policing.

Thus, the ORMVA is involved in the process of development and management of irrigation systems by identifying appropriate water allocation among crops and farmers, the determination of choices and management options that are made through hydrologic development studies, according to the specificities of each perimeter and the socio-economic context. The final choice of management options is decided after consultation with farmers through AWUA and Federation. The pricing of irrigation water through the pricing of irrigation water in accordance regulations such as the Agricultural Investment Code (Dahir 1-69-25).

The ORMVA's perception of governance is limited to water availability and use among farmers according to the plan set with users, water recovery and fees.

Source: Stakeholder interviews conducted in 2018 in Tadla region.

Box 4. Hydraulic Basin Agency (HBA) water governance perception.

Created in 1998, in lines with water Law 19/95, the main role of basin agencies is to promote an integrated, decentralized and concerted management of water resources. They intervene in consultation with all actors and sectors for better allocation of water resources, particularly through the programming of water allocations from dams.

Water fees are set by the Water Law 10 - 95 and should encourage polluters and water users to adopt more rational behavior towards water use and degradation. These fees, which aim to manage water, are coupled with an incentive for the agencies to invest in the conservation and protection of water resources, since the proceeds of the royalties are allocated to actions to clean up and conserve water resources. Through the public water use fee for irrigation currently set at 0.02 dh/m³, the agencies should contribute to financial aid for investments to modernize the forms of water uses by all sectors, including domestic uses. Through such fees and incentive, the agency is targeting the rational use of water, particularly a better valuation of the limited resources of the basin and sustain their uses.

HBA is a very powerful organization and whose intervention in the management of water is crucial. There is no doubt that water allocation decisions do not only concern agriculture, but also other sectors and also other regions, so the objective of equity and optimal uses among sectors is a priority. Water governance at the basin level is perceived as a rational and equitable allocation of water between sectors.

Source: Stakeholder interviews conducted in 2018 in Tadla region.

However, many of these technologies are not widely implemented or not seen as feasible by farmers. To address this, ICARDA developed the Community based Optimization of the Management of Scarce Water Resources in Agriculture in West Asia and North Africa project. Known as the Water BENCHMARK project, it is based on community participation in research and development, testing and adaptation of improved water management options at the farm level. The long term development goal of the project is the improvement of rural livelihoods in the dry areas of WANA by enhancing the productivity of agriculture based upon the efficient use and sustainable management of the scarce water resources from rainfall, groundwater and surface sources. The project selected Morocco as the benchmark for rainfed agriculture, Jordan for rangeland and Egypt for irrigated agriculture in addition to other satellite sites in seven other countries. Different water use systems were targeted in order to make comparison between countries.

It is not necessary that national governments take the lead in SDG/ODD6 implementation; local communities, NGOs, Civil Societies, policy actors and scientific group can have a significant effect. These latter are especially important and have a strong community-based research expertise on water that can contribute to the achievement of SDG/ODD6. For those who are willing to act on water access and security, one of the biggest tasks is to build new connections especially between those who traditionally do not cooperate much: private, farmers, politics and NGOs. Responsible communication, trust building and facilitation of cooperation are a key task in achieving sustainability and improving water governance in agriculture.

Water in the current approaches of managing it, is a highly technical and thus capital-intensive sector, with great risks that prevent investment where coordination is essential. Water policy is inherently complex and strongly linked to domains that are critical for development, including health, environment, agri-

culture, energy, spatial planning, regional development including job generation and poverty alleviation.

Coping with future water challenges raises not only the question of “what can we do?” but also “who does what?”, “why doing what?”, “at which level of government and society?” and “how?” Policy responses to meet water-related SDGs will only be viable if they are coherent, if stakeholders are strongly engaged, if well-designed regulatory frameworks are in place, if there is adequate and accessible information, and if there is sufficient capacity, integrity and transparency. Water governance systems should therefore be designed according to the challenges they are required to address.

To insure large access to water as a human right, all actors are asked to play a crucial role in improving their relation and be open to science. By introducing the concept of water governance platform, scientist and all actors must be agree on the role of the scientific evidence in improving water use and management in agriculture. So, the project team is trying to put together all actors and let them develop appropriate mechanisms to communicate and interact. Water management can and should be a leading example in the establishment of the platform. However, it's not an easy task given the behaviour diversity of actors and their objectives. The grant will be an opportunity to harmonise actors' objectives and interests.

It's important to notice that water stakeholder categories are ranked vertically, based on power, interest and legitimacy. According to these criteria, we can have dominant, forceful, influential, dormant, respected, vulnerable and marginalized actor. To set a sustainable collaboration or manage conflicts between actors means identify mechanisms that can reduce differences and push more collaboration that can I improve water governance.

In the context of climate change, the smart agriculture approach helps to identify appropriate management options and practices that can improve the productivity and resilience of production systems (FAO). This new approach includes soil conservation, improved irrigation and crop intensification and diversification. Different projects led by the *Institut National de la Recherche Agronomique* (INRA) in collaboration with the International Centre for Agricultural Research in the Dry Areas (ICARDA) and the other components of the National Agriculture Systems have targeted water management. Issues on water use efficiency, supplementary irrigation and water economic productivity were the millstones of the collaborative research programs between INRA and all other institutions. They were working closely to scale-up the adoption of ‘proven water technologies and interventions to boost productivity in large, medium and small scale irrigated agriculture’.

So enhance cooperation and coordinate between science and policy on water management in agriculture considering other sectors (economy, energy, climate change, health, food and biodiversity conservation etc...) is an urgent need. The objective of this initiative is to develop a platform for developing efficient, resil-

ient and inclusive water governance and integrated water resources management based on coordination across water stakeholders, ministries and all levels of government administrations and users, including local communities. Reinforce water governance of agricultural water can contribute to its efficient by considering science and technology.

Water is inefficiently used in production and along the entire value chain and in most sectors, including in agriculture, industries and households, for many reasons (negligence, water-inefficient processes, lack or quality of infrastructure, management and poor governance). Due to the absence of effective coordination intra and inter-sectors, for example between water, agriculture and environment, decisions taken in a given sector can have an adverse impact on water availability and quantity. The lack of policy coherence through effective co-ordination and harmonization has contributed to water degradation and its inefficient uses. Clearly allocate and distinguish roles and responsibilities for water policymaking, policy implementation, operational management and regulation, and foster co-ordination across these authorities are needed for the efficient water governance. Different strategies were established such as national water plan, the national plan for water economy, users organization, and the 36 - 15 water law.

Through the 36 - 15 water law Morocco (2015) is trying to transfer water management at the appropriate scale(s) within integrated basin governance systems to reflect local conditions, and foster co-ordination between the different scales. Up to now the situation is not clear and appropriate mechanisms are needed to operationalize the new regulation and empower water user associations (WUAs) as mechanisms to manage water at the relevant scale, recognizing that a minimum of financial, legal and technical support is needed for the WUAs to operate effectively. In cases, where water users are not organized, processes and structures may be identified to involve them in the governance of water resources.

Science and knowledge can play a key role in supporting policies and actor's strategies in managing water, mainly in agriculture. Scientific evidence can facilitate implementation of sound water management decision-making based on integrated scientific understanding, innovative technologies and local knowledge. By producing knowledge, scientific research can strengthen the science-policy interface ensuring and push research to go beyond academia and enables decision makers and civil society to achieve the water-related sustainable development goals. Co-design effective solutions and promote technology transfer programs towards a sustainable water efficient uses.

Since 2007, agricultural research institution (INRA Morocco) in collaboration with other national institutions and overseas expertise have initiated a the idea of bridging research and policy as a solution of valuing research output, implement sound agricultural policies and develop appropriate research programs. To do so, the organizers have limited talks and discussions on water use efficiency by wheat in arid zones. The main output is the absence of connection between

research and policy and more efforts are needed from both parties including media. All participants agree that science evidence can play a crucial role in implementing water policies. The challenge now is to have soft structures and networks that can facilitate the connection between policy and science. Trying to identify the relevant mechanisms and key actors that can push policy makers to use science evidence in water governance is not an easy task but it can be experimented in a limited area such as Tadla irrigated perimeter in the center of Morocco.

Within this complex social and climate context, developing a water governance platform where it will be possible to discuss and exchange ideas on optimizing water use efficiency and management on the basis of science output. According to what was presented, the main question is how science evidence can support the United Nation SDG6? The case of water governance in agriculture is considered to present effective recommendations and actions.

The limits of water supply management have opened other options for water management based mainly on water demand. Morocco is lagging far behind in this field, as supply policies are perceived, as more effective, besides the fact that large alternatives (dams, etc...) can be considered as a political legitimization. So, water demand management involves political, economic, institutional, legal and technical choices that can lead violent debates on water management in agriculture. Thus, the question arises of the trade-offs to be made between urban and agricultural uses, which are by far the most expensive. These trade-offs are not always based on cost-benefit ratios and negative externalities, especially environmental ones, but rather on political considerations that may be very important. Water is one of the most important factors that affect crops performances and household income. However, water as a public good and a non-renewable resource, urgent improvement is needed through policy, technology and institutional alternatives. Supplementary irrigation system and associated technologies and policy options are available and can be adopted⁹.

In Morocco, rainfed production is dependent on low and extremely variable rainfall and, therefore, productivity is low and unstable. This is further affected by frequent droughts and continuing land degradation. One option that has the potential to provide large productivity gains is the use of supplemental irrigation in rainfed crops, provided that water is made available for irrigation. National Agriculture Research System (NARS) has to increase the adoption of improved technologies, and thus improve water productivity and livelihoods, in these environments where water is scarce. INRA as institution can lead this option and be an interface for policy development.

Finally, the law is clear about the regulations and actors responsibilities but it's not clear how all actors should work together. It is important to clarify the relationship that the Watershed Agency and the other actors must have. It is not

⁹Laamari A. (2015). Aversion au risque des agriculteurs des périmètres irrigués au Maroc et interventions de l'Etat: Cas du Tadla. Thèse Grade de Docteur en Economie. LM²CE FSJES/LEASR-INRA Settat, Université Hassan 1^{er} de Settat.

enough for the agency to coordinate the water supply without addressing the demand and also the opportunities offered by scientific research for the efficient use of water. Also, agricultural policy itself is source of problems if we consider localized irrigation techniques subsidy system. How to translate scientific results into policy measures to limit water wastage and improve farmers' incomes? Can water users effectively intervene in the management of water supply and demand as stipulated by the law of their creation?

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

- Belghiti, M. (2008). *Introduction au débat sur les institutions de gestion de l'eau*. Séminaire organisé par le projet BENCHMARK, Tadla, ORMVAD.
- Chevalier, J., & Bukles, D. (2008). *SAS²: A Guide to Collaborative Inquiry and Social Engagement* (p. 316). International Development Research Centre/SAG Publications India Pvt Ltd.
- Conseil Economique, Social et Environnemental (EESC) (2014). *La gouvernance par la gestion intégrée des ressources en eaux au Maroc: Levier fondamental de développement durable*. Auto-saisine no. 15.
- Garces-Restrepo, C. et al. (2007). *Irrigation Management Transfer. Worldwide Efforts and Results*. FAO Water Report n°32.
- Hulme, M, Wigley, T. M. L., Barrow, E. M. Raper, S. C. B., Centella, A., Smith, S., & Chipanshi, A. C. (2000). *Using a Climate Scenario Generator for Vulnerability and Adaptation Assessments: MAGICC and SCENGEN Version 2.4 Workbook*. Climatic Research Unit, UEA.
- Kroutil, L. A., & Eng, E. (1989). Conceptualizing and Assessing Potential for Community Participation: A Planning Method. *Health Education Research Theory*, 4, 305-319. <https://doi.org/10.1093/her/4.3.305>
- Laamari, A. (2015). *Aversion au risque des agriculteurs des périmètres irrigués au Maroc et interventions de l'Etat: Cas du Tadla*. Thèse Grade de Docteur en Economie. LM²CE-FSJES/LEASR-INRA Settat, Université Hassan 1er de Settat.
- Taheripour, F., Tyner, W, E., Haqiqi, I., & Sajedinia, E. (2020). *Water Scarcity in Morocco: Analysis of Key Water Challenges*. World Bank. <https://openknowledge.worldbank.org/handle/10986/33306>