Water management and irrigation governance in the Anthropocene: moving from physical solutions to social involvement

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ABSTRACT

The rising water turbulence in the Anthropocene changes the water research and policy agenda, from a water-resource efficiency to a water resilience focus. Irrigation systems, as examples of complex social-ecological systems, deal with both the uncertainty of ecosystem dynamics and the interdependencies resulting from human needs. The water-agriculture nexus is context-dependent, socially constructed and technically uncertain, and it should be analysed as a hydrosocial cycle, which likewise takes into account the inseparability of social and physical aspects of water systems. Water management options have typically been categorized as either supply management or demand management, and even though physical solutions continue to dominate traditional planning approaches, these solutions are facing increasing social opposition. Focused on the Anthropocene dynamics, how to ensure stakeholders' involvement? The value of stakeholder participation is to reduce the rigid influence of the technocratic state by devolving greater decision-making power to users directly invested in, and knowledgeable of, the management of natural resources. This paper aims to review key questions about water governance in order to promote the transition from being problem-oriented to proactive and forward-thinking management tools by ensuring social learning.

Keywords: Irrigation, water management, stakeholders, governance, climate change, Anthropocene

1. INTRODUCTION

Natural resource governance and management are "wicked" problems consisting of multidimensional interests and competing values among stakeholders and actors at multiple levels [1]. Traditional approaches based on simple, linear growth optimisation strategies overseen by command/control and sectorial governance have failed to account for the inherent unpredictability and irreducible uncertainty of dynamically complex systems [2,3,4]. That is, balancing complex and conflicting water demands among different interests is a difficult task [5,6,7,8]. Governments and communities are increasingly faced with governing major change processes in complex social-ecological systems such as irrigation systems. Finding ways to improve outcomes for people and their organizations, as well as meeting environmental objectives of such change processes, will require governance approaches that address the inherent diversity, complexity, and uncertainty of complex social-ecological systems [9,10]. In a context where water availability is not guaranteed, consumptive use of

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freshwater –urban water consumption, irrigation– reduces the opportunity for alternative consumptive uses, such as hydroelectricity production or municipal use, and affects non-consumptive human activities such as cultural, recreational, and educational activities [11,12]. Given these human-induced pressures on freshwater ecosystems, the modern freshwater policy must account for conflict between competing for freshwater uses to ensure equitable and efficient management of the resource [13]. Shaping multi-functional waterscapes that balance consumptive and non-consumptive uses of freshwater, while maintaining environmental flows for ecosystem services, is a goal for freshwater managers across the world [14]. This task is made increasingly difficult by accelerating anthropogenic climate change, and its effect on freshwater availability worldwide [15].

During the twentieth century, the 'hydraulic paradigm' justified state intervention in freshwater management, with national and regional governments damming and diverting water bodies in order to create hydro-electricity and irrigation schemes 'in the national interest' [16]. The ecological crises precipitated by this paradigm [17], as well as its tendency to exacerbate regional and local conflicts [18], has resulted in a vacuum in freshwater policy in the twenty-first century which is being filled by a variety of different water management techniques [19]. Typically, water managers have responded by either developing alternative sources of productive water, modifying current allocation methods, or conserving existing resources [20,21]. What unites these new approaches are that over the past three decades, environmental policy has evolved from a top-down process engineered by public administration and state agencies toward a more decentralized process characterized by public-private partnerships focused on consensus building and self-management by stakeholders [22,23,24].

The shift from 'government' to 'governance' is one of the more noteworthy developments in contemporary social science [25]. It marks a transition from hierarchical to more network-based forms for decision-making, and a diffusion of boundaries between private and public actors. Management and governance are not mutually exclusive [26,27]. Management interventions also involve uncertainty, negotiation, deliberation, and sensitivity to social-ecological dynamics [28]. According to Armitage, de Loë and Plummer [29], recognition of the similarities and differences among management and governance is crucial given the complex, nonlinear and cross-scale nature of conservation challenges in an era of global environmental change. There are several definitions of governance, but they all deal with the array of actors and structures mobilized in water policy formulation and implementation [30,31]. According to the OECD (2015), effectiveness, efficiency, and trust and engagement are the three main principles of water governance. The first is related to the contribution of governance to define clear sustainable water policy goals and targets at all levels of government, to implement those policy goals, and to meet expected targets. The second one is focused on the contribution of governance to maximise the benefits of sustainable water management and welfare at the least cost to society. And the third one refers to the contribution of governance to building public confidence and ensuring inclusiveness of stakeholders through democratic legitimacy and fairness for society at large. In fact, governance arrangements are often judged on their ability to overcome tensions or conflicts between stakeholders [32,33,34]. One example of how to overcome these tensions is the promotion of Participatory Irrigation Management (PIM), an example of a governance approach which aims to improve water allocation and the effective use of water within agricultural systems [35,36]. PIM also promotes the participation of water users in all phases of irrigation management, such as planning, operation, maintenance, monitoring, and system evaluation [37]. This shift from a technocratic "top-down" to a more integrated "bottom-up" approach is also based on the increased awareness that today's freshwater problems are complex, requiring integrated solutions and a legitimate planning process [38. In fact, questions about who is included, or who is excluded, from environmental governance

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arrangements are at the heart of debates of institutional legitimacy [39,40]. This review paper therefore will emphasize on topics included the management of irrigation systems taking into account Anthropocene dynamics.

2. MULTIFUNCTIONAL IRRIGATION SYSTEMS AND THE ANTHROPOCENE COMPLEXITY

Humans have long sought ways of capturing, storing, cleaning, and redirecting freshwater resources in efforts to reduce their vulnerability to irregular river flows and unpredictable rainfall [41]. Choices for agricultural water management include a large range of technical, infrastructure, economic, and social factors [42,43,44]. Irrigation systems, as examples of complex social-ecological systems, deal with both the uncertainty of ecosystem dynamics and the interdependencies resulting from Anthropocene complexity. The Anthropocene marks our time as one in which Earth’s form and functioning has become inextricably entangled with the workings of human societies [45]. This concept suggests that such collaboration, perhaps based initially around a global spatial database of Anthropocene impacts, is not an impossible dream [46]. The need for environmental scientists to communicate increasingly more effectively with political and business leaders, as well as the general public, is another shared theme of the Anthropocene literature, reflecting the recognition that humans’ activities are at the core of both the problems and solutions [47,48]. One of this activities is irrigation because water-agriculture nexus is context-dependent, socially constructed and technically uncertain, and it should be analysed as a hydrosocial cycle, which likewise takes into account the inseparability of social and physical aspects of water systems. Irrigation systems have been under pressure to produce more with lower supplies of water [49,50]. Agriculture water needs must be supplied in a context of diminishing availability, due to environmental awareness, population growth, economic development and global change [51,52]. As a consequence, water management for agriculture is interrelated not only to traditional water resources management, but also to food production, rural development, and natural resources management [53].

European irrigation practices have traditionally consisted of gravity-fed surface irrigation systems [54]. In these cases, the water is conveyed from surface sources (primarily rivers or reservoirs, both natural and artificial) and is distributed to the individual fields through a network of canals of different sizes, relying on gravity as the driving force [55,56]. The European rural mosaic is based on a combination of ancient irrigation systems and modernised or new irrigation projects, which were promoted based on the guarantee of water efficiency and food security [57,58]. In both contexts, hydraulic constructions have played a central role in the attempt to dominate water and land resources, where the agrarian plains have played a key role in developing irrigation [59,60]. Water management options have typically been categorized as either supply management or demand management [61]. The former is focused on enlarging the amount of resources available, while the second focuses on reducing the amount of needed for consumptive purposes [62]. Historically, civil and water engineers have focused on large-scale supply augmentation infrastructure projects, while economists and environmentalists have tended to advocate for efficiency improvements and conservation-oriented policies typically associated with water demand management [63]. Each approach has its relative merits. Supply-side policies enlarge the pie, promoting possibilities for increased economic activity and avoiding the difficult social and political obstacles involved in such demand-side options as cutting water quotas or increasing prices [64]. Demand management options are often cheaper, more economically efficient, and have less negative environmental impacts than supply augmentation [65].

3. BIG INFRASTRUCTURE FOR PLANNING WATER RESOURCES EFFICIENCY: BETWEEN INNOVATION AND OPPOSITION

A reliance on physical solutions continues to dominate traditional planning approaches, but these solutions are facing increasing opposition [66]. At the same time, new methods are being developed to meet the demands of growing populations without requiring major new construction or new large-scale water transfers from one region to another [67]. More and more water suppliers and planning agencies are beginning to shift their focus and explore efficiency improvements, implement options for managing demand, and reallocate water among users to reduce projected gaps and meet future needs [68,69]. Considering that water infrastructure outcomes are affected by a variety of social and political factors, it is logical and desirable that water infrastructure planning, and the frameworks that guide it, should explicitly address and incorporate these factors [70,71]. That is, the field of water utility management, which was traditionally an engineering-based and technical practice, is now far more complex, with many interrelated factors to consider [72]. Theoretically, economic factors drive farmers' decision-making processes in adopting irrigation technologies and applying water management practices and maintenance operations [73]. These decisions are made to maximize their net incomes [74]. In this regard, irrigation uniformity plays a relevant role in investment and operational costs of centre pivots and, hence, in farmers' profits [75]. However, social factors such as education, social status, water governance or cultural context, among others, also affect these decisions [76]. For these reasons, socio-economic contexts should also be considered along with technical and other factors for sound comprehension of the causes affecting irrigation performance and water management [77].

In the early 20th century, it was common to apply purely rational thinking to complex systems, when government consistently used expert-driven, science and economics based methodologies to determine policy on issues such as air-pollution regulation, and the creation of new dams or big infrastructure for irrigation projects [78]. These processes involved putting a number of experts in a room to attempt to objectively calculate what is best for society, but without taking into the society as a stakeholder. These types of government studies are typically referred to as “rational comprehensive planning” because they focused on experts doing quantitative analysis on all relevant factors to determine the best options for solving complex problems [79]. In the second half of the 20th century “rational” approaches to planning became unpopular in urban and rural planning and other areas of public policy, which moved on to a more socially oriented planning regime [80]. Since then, infrastructure planning practices however did not follow suit, and have remained largely rational, centralised, expert-driven systems up. In other words, from the 1950s onwards, infrastructure planning tended to remain in the old rational/technocratic paradigm, because infrastructure planning, as practised throughout history, had not been particularly complex and generally involved independent, segregated planning for each service and reactive upgrading as required [81]. For some authors, the only significant non-technical adjustment to infrastructure planning over the last century has been the inclusion of some level of community consultation, while for others infrastructure planning requires a “sociocratic” approach, that is, a general reorientation of urban planning away from architecture and engineering and toward economic, sociological, and political considerations [82].

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4. IS PARTICIPATION AN ADDED VALUE FOR MANAGING HYDROSOCIAL SYSTEMS? AN EUROPEAN EXPERIENCE

A cursory glance at the literature on water management and governance reveals that stakeholder engagement has long been considered an integral part of sound governance processes [83]. Proponents argue that the value of stakeholder participation is to reduce the rigid influence of the technocratic state by devolving greater decision-making power to users directly invested in, and knowledgeable of, the management of natural resources [84]. This shift from a technocratic “top-down” to a more social “bottom-up” approach is growing in popularity as water managers acknowledge that water problems are complex, requiring integrated solutions and a legitimate planning process. However, a closer look at the literature reveals that, beyond this general assertion, and despite extensive research, case studies and policies, there is a lack of evidence-based assessment on how effective stakeholder engagement processes have been in reaching intended objectives of water governance [85]. That is, empirical analyses suggest that without significant changes in the supporting institutions, governance arrangements and policy framework, the standard tools and models of water regulation will not be effective [86]. In addition, given the size and nature of water challenges, tackling them requires a co-ordinated effort among policy makers and stakeholders: those who play a role in, and who are affected by, actions and outcomes in each water context [87].

In this context, constructing and implementing successful dialogues encourages both governmental and non-governmental stakeholders to engage more often in the difficult, but productive, task of listening to and learning from each another [88]. Successful engagement depends on understanding who to engage with (key stakeholders), for what reason (scope, purpose, challenge), from what perspective (culture, values), and with what methods (techniques and tools) [89,90]. Including a broader set of stakeholders provides decision-makers with different kinds of knowledge which may be vital for a full assessment of a resource governance problem and for finding innovative solutions to it [91]. It has long been recognized that although planning is often represented as rational and objective, in reality it is inherently subjective and affected by social and political dimensions, as well as prone to unavoidable conflicts, famously described planning as “the science of muddling through” [92]. One only needs to look briefly into the decision-making processes involved in any major infrastructure project to discover just how subjective and political planning can be. That is, although planning processes are ideally informed by science and evidence, it is problematic to consider planning decisions as entirely objective or rational, as all are made by humans and are therefore open to interpretation and opinion.

Coping with current and future challenges to freshwater resources requires robust public policies, relying on a clear assignment of duties across concerned stakeholders who are subject to regular monitoring and evaluation [93,94]. Water governance and stakeholder engagement can contribute to the design and implementation of such policies and frameworks, by sharing responsibility across scales of government, civil society, and private actors. That is, cooperation and information sharing strongly influences the social acceptance of irrigation measures and actions. The European Water Framework Directive (WFD) is one of the most encompassing and ambitious policy programs in regards to water protection and management [95]. The WFD mandates that European state members produce planning documents that detail how ‘good water status’ will be reached by 2015, or at the latest by 2027. These planning documents are prepared and updated in six-year cycles and require citizen and stakeholder participation in their creation [96]. This ‘mandated participatory planning’ approach [97] and common timeframe for WFD implementation across European member states provides an excellent context to compare the effectiveness of participatory environmental governance [98]. The WFD is based on the concept of

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Integrated Water Resources Management (IWRM) which was developed during the 1990s. IWRM was defined by the Global Water Partnership as a process which promotes the coordinated development and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. In substantive terms, the WFD and its related policies are the main pieces of legislation for the protection and sustainable use of European freshwater resources [see 99]. The WFD follows the receptor-oriented management principle and focuses on an assessment of biological, hydro-morphological, chemical and physico-chemical quality elements in all European river basins, acknowledging that ecological and human health impacts are multiple-stress responses [100]. In procedural terms, the WFD belongs to a new generation of legal regulations that combines traditional law with elements of new governance, such as the coordination of actions across policy levels and the active involvement of all interested parties in the implementation [101]. Participation is required for the elaboration of the 'river basin management plans', which are the central planning instrument of the WFD, and it calls for three types and intensities of participation: comprehensive information, consultation and active involvement [102]. There is, however, no prescription on who should be involved in the planning process, at what stage they should be involved and how. As such, the WFD leaves member states with considerable leeway in this regard [103]. According to this, most river basin districts have established permanent organisational structures called water councils which are comprised of representatives of a series of organisations (environmental NGOs, local farmers, local enterprises, citizens, and so on).

5. TOOLS AND STRATEGIES FOR GOVERNING CONFLICTS IN MULTIFUNCTIONAL WATER BODIES

Including stakeholder participation in decision-making processes is especially relevant when authorities are trying to manage freshwater according to natural functions and human demands [104]. This entails the need to develop better mechanisms than the previously reductive engineering-centred techniques of the hydraulic paradigm. In addition, successful participation of stakeholders in natural-resources management requires decision-making tools that are transparent and flexible [105]. These tools should be designed to elicit knowledge from different stakeholder groups and operate as a platform to carry out the debate [106]. The following examples provide some local experiences selected from their innovative character and significance, with the aim of provide ideas for improving the perception of participation as a benefit of multifunctional water systems management.

5.1 Spain: When water exchange guarantees water supply

The coexistence of the so-called *humid Spain* (north and northeast of the country) with the south and south-east, known as *dry Spain*, together with a significant development of the tourist sector, a large water user, in the driest area of the country, has given rise to the emergence of water management practices with local characteristics [107]. In this context, water problems have two dimensions: the physical dilemma of irregular distribution in terms of time and territory, and the politico-institutional complexity of a management of water resources which has been focused for a long time on supply-side approaches associated with a series of negative environmental impacts, in particular, reservoirs, basin transfers and desalination [108]. In certain areas with scarce water resources or where water resources are the cause of conflict between competing demands, it is possible to conciliate the interests of different users in a stable way through an integrated and inter-administrative water management. An integrated system of this kind was implemented in the Marina Baja District in the mid-1980s, and is now fully consolidated. The Marina Baja district, in the

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south-east of the Iberian Peninsula, forms part of the province of Alicante, and falls under the administrative jurisdiction of the Júcar River Basin Authority. The urban demand has a high seasonal component related to tourist and agricultural activity in the area. The relationship between the two is what characterises the integrated nature of the model. Created in 1977 as an example of a mixed water management agency, the Marina Baja Water Consortium was able to integrate the management of surface, groundwater and unconventional water resources for supply and agricultural water uses [109]. The aim of the consortium is to guarantee the integrated management of water resources in the region and to maintain water infrastructure (reservoirs, aquifers and wastewater) to assist agricultural and urban-tourist water supplies through the exchange of conventional (surface and underground water) and non-conventional water (treated water). This management model would not make sense if it were not based on the agreement between irrigators and suppliers (municipalities). In fact, the main condition for establishing these agreements is the regular and direct dialogue between end users and technicians of the consortium [110].

5.2 France: When the debate is part of the decision-making policy

Social involvement in environmental questions and the management of water resources has evolved in France from environmental opposition of the 1970s and 1980s to the eco-citizen participation since the 1990s. The Barnier Law *(Loi Barnier, relative au renforcement de la protection de l'environnement, 1995*) is, until today, the most successful French legal tool in the process of promoting participatory democracy regarding environmental and natural resources issues. This law promotes public participation and involvement in the pursuit of territorial projects able to have a significant impact on the environment. The Law provides a tool, named the National Commission of the Public Debate (CNDP, *Commission nationale du débat public*) as institution created in order to decide on the need to provide a prior public debate about any territorial project that entails a landscaping and environmental impact [111]. Established in the early 1990s, this mechanism promotes a new form of public consultation in those projects capable of given rise to environmental impacts in natural resources and socioeconomic activities. Since its creation, about 190 projects have been debated as part of this consultation process organized by the CNDP. Many projects have been modified; nearly twenty have even been abandoned. Among the latter group, it is noteworthy the proposal for developing a reservoir in Charlàs, in the Neste irrigation system, located in the Southwest of France. The aim of the project was to provide a partial response to the structural deficit of the water resources of the Garonne basin resulted from a drought period which affected the Lannemezan valley in the 1980s. In 1988 local administration promoted the construction of this reservoir in order to 1) permanently guarantee the quality of the environment and the drinking water supply of the populations and 2) support the regional economies of Val de Garonne and Gascony. In 1996, the Bassin Adour-Garonne Committee welcomed the project to build the dam and a year later, due to the territorial dimension of the project, the environmental NGO France Nature Environnement called for a social discussion through a Public Debate process. To this end, in 2003 the Public Debate Committee was created to organize the participation process and from September to December, meetings were held open to stakeholder participation (both geographically and by sectorial involvement). The scope of the process was: 10 meetings, 4,214 participants, 29 experts, 348 opened questions, and a cost of 569,958 Euros. The infrastructure development changed as a result of this process, but it still recognised the need to act in order to prepare for water shortages in the Lannemezan area. The formal process of Public Debate closed, but the informal debate on the management of water as a scarce resource still continues in the region.

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In 2015 after several controversies about the level of governance and legitimacy stipulated in the acceptance or rejection of projects with environmental impact –like the Charlàs reservoir proposal– the CNDP considered that it would be useful to simplify procedures by reducing direct consultation to citizens. This idea was supported by a colloquium entitled “Citizens and public decision-making, legitimacy and effectiveness” prepared by TNS Sofres surveys enterprise, where more than 90% of participants endorsed the policy. In March 2015 the CNDP published several of these proposals, all aimed at strengthening public debate, public consultation, and environmental dialogue. In particular, it advocated: 1) to allow 10 parliamentarians, 10,000 citizens or an environmental protection association to self-identify whether the project is of national interest or not; 2) to allow legislatures and / or 500,000 citizens to request a public debate on general plans, programs or options (a measure provided for by the *Grenelle Law*); 3) to guarantee a continuum of collective participation in the public debate and public utility investigation at the end of the project; 4) encouraging independent counter-expertise more than contracting authorities and project-makers; 5) encouraging citizens’ conferences as it was demonstrated that pluralistically trained citizens could make a relevant and circumstantial judgment on the most complex issues; and 6) the CNDP have to reconcile conflicting projects as an organism seized by the various stakeholders involved into the projects. In 2017, new participation tools (Table 1) have been considered in order to promote social involvement by increasing direct and regular contact with stakeholders and the public.

Table 1. Projects submitted to a public debate process (2017-2018)

Current projects	***Tools for social involvement***
Revision of the multi-annual program on energy	Local meetings
	Participatory webpage
	Questionnaire
Industrial gold mine in French Guiana	Survey
	Electronic letter
	Facebook / Twitter
Geraniums Tourism route	Public hearing sessions
	Conference cycle
	Facebook campaign
	Public and thematic meetings
	Unfixed debates
	Students’ meetings
	Discussion forum

5.3 Italy: An agreement to overcome stereotypes

In 2007, after a series of droughts occurred last two years, the Lombard region proposed a water agreement, The Patto per l’Acqua, as a mechanism for managing multiple coexisting consumptive and non-consumptive water uses. The aim of the agreement was to: 1) coordinate existing water storage capacity; 2) promote tools for water use efficiency in the agricultural sector; 3) invest in sustainable crops; 4) improve flood capacity; and 5) develop new tools for ensuring direct and clear information. Although its origin from an emergency situation, the main objective was to ensure the water resilience of the Lombard region from increasing co-responsibility actions in order to respond to the more than foreseeable climate

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change scenario of decreasing water availability for the 2020-2025 time horizon. In fact, the ability to promote governance was included in the strategic lines of the agreement from different actions [112]. Firstly, organizing events on water activities, awareness-raising campaigns on the value of water, as well as the life and balance of the entire system, not only in terms of water supply to the tap, the only value perceived by the citizens. Secondly, including the management of freshwater in educational programs. Finally, creating a network for sharing data and successful pilot experiences among end users.

The process of creating the water agreement was structured in five working groups: 1) evaluation and updating of the management of the reservoirs, 2) analysis on the efficiency of water management for agricultural use and irrigation systems, 3) sustainability and climate change adaptation of crop types, 4) structural allocations to manage and assess water resources, and 5) instruments and actions to collect and disseminate accurate information to the citizens. The application of a creative methodology (based on the “de-structuring of the problematic” to abandon stereotypes, prejudices or false beliefs and begin to establish new points of view through the knowledge of the other) allowed the establishment of a new set of rules: freedom of expression and legitimacy of all opinions, validation of all contributions regardless of the role represented, obligation to listen the other and to put oneself in the other’s place, and the challenge of transforming each water demand into proposals elaborated from an heterogeneous points of view. One of the most surprising practices applied in the process was the method devised to understand the point of view of the other, named “the dialogue between masks”. On the basis of this method, each stakeholder puts on a Greek theatre mask with which he formulated questions and interacted with other stakeholders in order to overcome those stereotypes associated to each stakeholder.

The 66 signatory stakeholders represented public administration at different scales, different water management bodies, consortia, public parks, agricultural unions, irrigators’ associations, environmental platforms, the energy sector and university. All agreed a total of six lines of action to be developed jointly: 1) the cultural approach, understood as the ability to disseminate and sensitize the reality of water resources in the region; 2) the ability to share information among stakeholders; 3) the promotion of river basin programs as a mechanisms to coordinate the consumptive water uses; 4) the prioritization of the good ecological status of rivers and lakes; 5) the optimization of water use in agriculture; and 6) the investment in infrastructural actions in order to ensure the efficiency of the water network. Although the commitment to this pact has been a clear and innovative example of a willingness to change water management from increasing the governance of the process, the main criticism received comes from its weakness of implementation, since it is a voluntary agreement that has not had continuity beyond the year in which it was proposed.

6. DISCUSSION

The Anthropocene, a proposed geological epoch in which humanity is positioned as the core driver of planetary change, is redirecting attention to how multifunctional human-natural systems are managed according to climate change [113,114]. Human-environmental conflicts and water management debates are increasing globally [115,116]. Literature on natural resources conservation and natural resources management highlights two important factors that affect the success with which these conflicts can be tackled. First, stakeholders’ perceptions of others and of the issues exert a strong influence on management ‘problems’ and acceptable solutions [117]. Second, it is essential that participatory processes address the ecological, economic and social consequences of different land and water management alternatives in an integrated manner, because conflict often emerges where resource users pursue disparate management objectives based on differing values [118]. Both factors

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confirm that participation is valued for its potential to enhance the effectiveness of governance by improving the ability of drivers to be involved on the water management paradigm [119]. However, it will therefore be crucial to determine whether, and under what conditions, stakeholders' participation improves the level of governance and promotes the integrated management of water resources where and when water is a limiting factor. In theory, collaborative processes offer a mechanism through which natural resources management can be achieved in a partnership capable of delivering mutual and multiple benefits from sustainability issues [120]. They can help to increase understanding and in doing so, allow different human demands to be negotiated and natural resources to be managed. In practice, however, there is a tendency for environment management to focus on one of the three aspects of sustainability, usually environmental sustainability.

How to resolve this puzzle? Arguably, the 'success' of participation measured in social terms depends on various aspects of the wider context within which processes are situated and, more importantly, on the characteristics of the participatory processes themselves, such as the inclusion and influence of different interest groups. Stakeholder empowerment encourages 'ownership' of decisions, strengthens trust among all partners, and can reduce conflict. However, stakeholder participation requires an investment of time and resources, and the ability to recognize and address different points of view. In the case of multifunctional irrigation systems, social 'endorsement' and stakeholder engagement must be understood as complementary to the administration and leadership of the participation process. However, one of the main risks of participation is when the recommendations of collaborators and key stakeholders remain non-binding on local governments and public administration. According to this, social learning has to include: (1) a change in understanding multifunctional irrigation systems; (2) a change goes beyond the individual to be focused on the involvement of the community; and (3) social interactions and learning processes among stakeholders with confronted water interests. These factors confirm that as many stakeholders are involved to resolve a particular issue, irrigation management institutions must undergo a transition from being problem-oriented to proactive and forward-thinking, incorporating confronted interests and promoting social learning. In fact, these three aspects must work to improve the exchange of points of view amongst key stakeholders to define a strategy able to address Anthropocene challenges. Increasing *comprehension* (the ability to put oneself in the place of the other, sharing social identity, and promoting collaboration between different viewpoints) is useful to convert competing demands into practical solutions, as occurred in the 'dialogue between masks' (promoted in the Italian case study). In fact, participatory processes tend to focus on collaboration rather than on comprehension, which makes it difficult to understand the rationale behind each stakeholder demand. According to this, the comprehension is a key issue for promoting social involvement in irrigation systems management, as a first step to put in balance how ancient and new irrigation projects are able to integrate the management of water resources with the involvement of political, economic, environmental and social drivers. This process is complex because it requires taking into account technical issues (the availability of natural resources) and social issues (interpreting stakeholders' demands to irrigation systems). It is also necessary to consider the existing and potential conflicts that arise between consumptive and non-consumptive water uses, especially in water stressed contexts.

7. CONCLUSION

Irrigation systems, as examples of complex social-ecological systems, deal with both the uncertainty of ecosystem dynamics and the interdependencies resulting from Anthropocene complexity. Debates over irrigation management and governance have increasingly been framed in relation to social, economic, environmental and cultural impact, stimulating policy

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framework changes at different scales. That is, the water-agriculture nexus is context-dependent, socially constructed and technically uncertain, and it should be analysed as a hydrosocial cycle, which likewise takes into account the inseparability of social and physical aspects of water systems. The provision of water governance tools, strategies and policies are much more than simply finding technical (or technocratic) solutions for matching, in space and time, and in quantity and quality, water uses and water availability. The “context” is of fundamental importance: Who makes decisions? What type of instruments can be used? Through what kind of processes and institutions can water challenges be addressed in order to ensure that the Anthropocene will be managed from social-learning processes? Which actors and segments of civil society ought to be interacted and engaged with? According to French and Italian case experiences, a lack of involvement of stakeholders in decision-making processes can be cause of frustration between the theoretical aims about public participation and realistic engagement promoted by the official agenda. In order to revert this situation, any decision-making process has to provide a team of facilitators able to determine and adapt the participation process to reconcile confronted water interests.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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