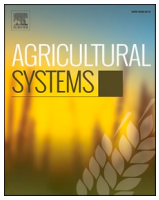
Agricultural Systems 204 (2023) 103552

Contents lists available at ScienceDirect

Agricultural Systems

journal homepage: www.elsevier.com/locate/agsy



Communality in farmer managed irrigation systems: Insights from Spain, Ecuador, Cambodia and Mozambique

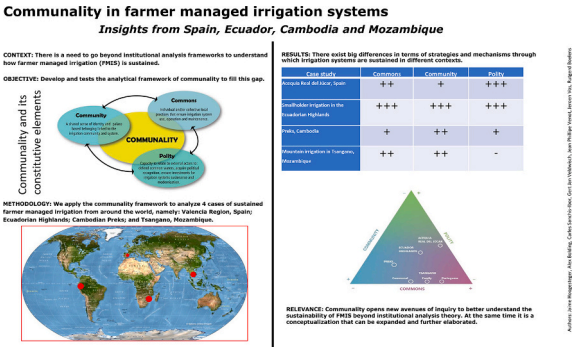
Jaime Hoogesteger [a,*], Alex Bolding [a], Carles Sanchis-Ibor [b], Gert Jan Veldwisch [a], Jean-Philippe Venot [c], Jeroen Vos [a], Rutgerd Boelens [a,d]

[a] Water Resources Management Group, Wageningen University, the Netherlands
[b] Valencian Centre for Irrigation Studies (CVER), Universitat Politècnica de València, Spain
[c] French National Research Institute for Sustainable Development (IRD), Université de Montpellier, France
[d] Centre for Latin American Studies and Documentation, University of Amsterdam, the Netherlands

HIGHLIGHTS

- We need new frameworks to understand farmer managed irrigation systems (FMIS) sustainability.
- This paper develops the analytical framework of communality to fill this gap.
- Four cases of sustained FMIS are analyzed through communality.
- Differences in strategies to sustain irrigation systems are identified.
- Communality opens new avenues of inquiry to better understand the sustainability of FMIS.

GRAPHICAL ABSTRACT



ARTICLE INFO

Editor: Jagadish Timsina

Keywords:
Water collectives
Irrigation
Collective action
Political agency
Community

ABSTRACT

CONTEXT: Worldwide farmer managed irrigation systems have provided crops for food, feed and the market for centuries. From high mountain environments to river valleys and deltas, in all continents people have organized to construct, use, maintain, transform and sustain irrigated agro-ecosystems. In this context it is important to better understand how these systems are sustained.
OBJECTIVE: The objective of this contribution is to explore and theorize through which strategies and mechanisms irrigators are able to sustain these systems in a constantly changing socio-environmental context.
METHODS: The study is based on ethnographic qualitative research in four areas where farmer managed irrigation systems are sustained by irrigators (Valencia region, Spain; Ecuadorian highlands; Cambodian Mekong delta; and Tsangano district, Mozambique). Research consisted of interviews and observations in these areas and was supported by a literature review of what has been published about these systems.
RESULTS AND CONCLUSIONS: Results show that farmer managed irrigation systems are dynamic systems that constantly transform but that are sustained in these changes through what we term '*communality*'. We introduce this term to point out three interrelated elements that stand at the basis of farmer managed irrigation systems sustenance, namely: commons, community and polity. Analysis of the four case studies points out that these three

* Corresponding author.
E-mail address: jaime.hoogesteger@wur.nl (J. Hoogesteger).

https://doi.org/10.1016/j.agsy.2022.103552
Received 1 August 2022; Received in revised form 30 September 2022; Accepted 20 October 2022

elements are mobilized differently by farmers depending on their socio-environmental context. We show that the mobilization of these different elements amidst internal and external challenges and conflicts, forms the basis for the longevity and sustainability of collectively managed irrigation systems.

SIGNIFICANCE: In the literature on farmer managed irrigation systems collective action has been portrayed as the main pillar that sustains these systems. This contribution challenges this notion by showing that irrigation systems are sustained by a combination of individual actions, collective practices, normative frameworks and organizational forms; a sense of community; and the development of political agency (polity). Recognizing that these elements come together as site specific hybrids opens new avenues of inquiry to better understand the sustainability of farmer managed irrigation systems.

1. Introduction

User managed irrigation systems are for many rural communities around the world the basis to access water for agricultural production and other uses. For millennia user managed irrigation systems have supported agricultural production and related rural livelihoods by guaranteeing a fairly secure water supply that allows for extended cropping seasons, double or triple cropping, and the production of crops that would not thrive under rainfall conditions. Irrigation systems have been constructed and used in almost all climates and geophysical settings around the world. Some examples include spate irrigation and qanats in the deserts of the Middle East and Mediterranean Regions; mountain irrigation systems in the European Alps, Himalayas (Asia), Andes (Latin America), Rocky Mountains (North America) and along the slopes of the Kilimanjaro (Africa); irrigation in valley bottoms (*bas-fond and dambos*) in Sub-Saharan Africa, reservoir based (tanks) systems in India, and irrigation through flood control in fertile deltas of many larger river systems around the world. User managed irrigation systems cover a broad spectrum, from small systems with only a few smallholders that capture and distribute water collectively to (ancient) large irrigation systems of over 100,000 ha made of interconnected networks of small systems that stretch over large areas and incorporate thousands of users such as the large irrigation systems in the desert coast of Peru (Vos and Vincent, 2011) and the 20,000 ha of interconnected Subak systems on Bali (Roth, 2011).

Overcoming social, physical and ecological transformations is part and parcel of user managed irrigation systems' functioning. When water scarcity or socio-economic uncertainty prevail, conflicts tend to arise as users struggle to gain or maintain their access to water to ensure agricultural production (Aubriot, 2022; Agrawal and Gibson, 2001). Despite recurring challenges, many user managed irrigation systems have been able to overcome these through a process of constant adaptation and transformation. These transformations take place in different yet interrelated realms such as the agricultural/productive, the organizational and normative, the cultural, the economic, the technical/infrastructural (Boelens and Vos, 2014; Poussin et al., 2006). In doing so, users engage with each other, irrigation infrastructure and the environment as well as with their broader environmental context and external actors, such as users of other irrigation systems, the state, non-governmental organizations, engineering companies, markets and more (Berthet and Hickey, 2018; García-Mollá et al., 2020; Mirhanoğlu et al., 2022).

In the last century the world population has strongly urbanized and globalized, intensifying the relations between the urban and rural and the far and the near, triggering agrarian transitions (Hoogesteger and Rivara, 2021). These influence rural lives and cultures through the diversification of livelihoods, lifestyles and peasant economies with important impacts on how people relate to agriculture and irrigation (Baumann, 2022). In spite of these changes irrigated agriculture still plays a fundamental role in many rural communities and their economies contributing to local food security, rural livelihoods and rural labor demands, as well as in the recreation of cultural practices and relations, place identity and related community (Aubriot, 2022; Boelens and Hoogesteger, 2017; Reyes-Escate et al., 2022).

Departing from this context, in this contribution we aim to explore, better understand and theorize how users re-create their (ancient) irrigation systems to ensure their longivity (Abdullaev and Mollinga, 2010; Aubriot, 2022; Mirhanoğlu et al., 2022; Misquitta and Birkenholtz, 2021). To do so we use the notion of *irrigation communities* which we define as the group of people that use, relate to, and identify with an irrigation system (Boelens, 2014; García-Mollá et al., 2020). We furthermore depart from a socio-technical understanding of irrigation systems (Bolding et al., 1995; Mollinga, 2013). This understanding recognizes that the natural environment (climate, water, soil, topography), the social world (culture, economy, institutions) and the technical (hydraulic infrastructure and agricultural technologies) are intrinsically related and mutually constitutive or in the words of Shah and Boelens, 2021 'all at once' (see also Hommes et al., 2022). Changes in one of the dimensions always has implications on the others. In this contribution we take the social dimension as entry point and theorize it as pivotal in mediating adaptations in the natural and technical dimensions of irrigation systems. To do so, we develop the notion of 'communality' which intertwines the concepts of commons, community and polity as three fundamental pillars that guarantee the recreation of the social fabric that sustains irrigation systems. We use this concept to inform our analysis of several cases of sustained user managed irrigation systems, namely a traditional irrigation system of the Valencia region Spain, smallholder managed irrigation in the Ecuadorian Andes, the Cambodian Preks, and farmer led irrigation development in Tsangano District, Mozambique.

The article is structured as follows. After this introduction we present the research methodology, then we present the notion of communality and its sub-components followed by the analysis of the four case studies that inform this contribution. These different cases are analyzed through the notion of communality and show how different elements of this notion manifest distinctively in every case. In section five we compare the four cases. In the conclusions we reflect on the notion of communality and how it helps to better understand the longevity of traditional irrigation systems in very different contexts.

2. Methodology

The study is based on ethnographic qualitative research in the four case studies. For data collection different ethnographic research methods to study collective action were used (Meinzen-Dick et al., 2004). These methods consisted of open and semi-structured interviews with policy makers, bureaucrats, staff from development agencies, leaders and ex-leaders of the irrigation communities, irrigators, technicians working for the irrigation communities and technical staff of non-governmental organizations supporting these irrigation communities. Personal notes of these interviews were made and in cases where permission by the interviewees was granted, interviews were audio-recorded. Field observations (Strauss, 1987) in the irrigation systems were likewise recorded in the researchers' personal notes. Participatory observations (Clark et al., 2009) were done during events organized and/or attended by the irrigation communities during the researchers' fieldwork periods and, in some cases, researchers engaged in participatory research activities. Aside from these primary sources of information, annual reports, statistics and where existent websites of the

irrigation communities were retrieved and analyzed. In the cases where state agencies and/or NGOs supported the irrigation communities through projects, the project reports and working documents were retrieved and analyzed. A detailed methodology description for each of the cases can be found in for: Spain (García-Mollá et al., 2020; Sanchis-Ibor et al., 2021), Ecuador (Hoogesteger, 2013a), Cambodia (Ivars and Venot, 2018; Venot and Jensen, 2022; Venot and Jensen, 2022), and Mozambique (Nkoka et al., 2014).

The development of the theoretical framework was informed by -and builds on- interdisciplinary literature on irrigation studies, collective action and community based natural resources management. It especially builds on earlier insights, theory and frameworks developed by the authors in Boelens (2014), Boelens and Hoogesteger (2017), Hoogesteger (2013b), Hoogesteger and Verzijl (2015), Ivars and Venot (2018), Venot and Clément (2013), Vos et al. (2020), Woodhouse et al. (2017), Veldwisch et al. (2019) among others. In analyzing and reworking these theoretical insights we focused on developing a framework that allows for a better understanding of how and through which social mechanisms irrigation communities sustain their systems. Specific attention was given to develop a framework and related analytical tools that better explain why some irrigation systems are sustained where classical collective action research (see for instance Ostrom, 1990, 2007, 2009) would predict contradictory outcomes. From this perspective the developed theoretical framework of communality offers new analytical tools that build on-, and expand, earlier theoretizations.

3. Communality in irrigation systems

Many scholars have posed that collective action is the basis for the sustainability of user managed irrigation systems. Through collective action basic infrastructure and water flows are managed and maintained allowing users to access water for irrigation and sometimes other uses at plot level. Economists inspired by the work of Ostrom (1990, 2007) have identified factors that influence the levels and probability of collective action for irrigation system operation and maintenance (Mushtaq et al., 2007). They show that, among others, a relatively secure water supply, clarity in system boundaries and related sharing of responsibilities, a high dependence of users' livelihoods on irrigated agriculture, close access to agricultural markets, homogeneity in users, and the presence of other local organizations positively impact the levels of collective action in irrigation systems (Bardhan, 2000; Poteete and Ostrom, 2004; Araral Jr, 2009). However, many user managed irrigation systems have proven to persist and continue to be operational despite many odds that would indicate low levels of collective action (Boelens and Seemann, 2014; Sanchis Ibor et al., 2017; Paerregaard, 2018; Villamayor-Tomas et al., 2020). To better understand this, we turn to more anthropological research approaches and focus specifically on the notion of communality.

The notion of *communality,* which we develop here, offers the opportunity to further explore how irrigation collectives re-create and sustain their irrigation systems through very different strategies that go beyond the classic notion of collective action. Communality is defined by the Collins Dictionary (2022) as 'a feeling or spirit of cooperation and belonging arising from common interests and goals' or 'the state or condition of being communal' without it having to be grounded only or necessarily in institutionalized collective action (see also Esteva, 2014). We take this notion of 'a communal subject' and 'an active we' as departure point and bring it together with the notions of *commons, community* and *polity* as constitutive elements of *communality* (See Fig. 1). *Communality,* in the context of farmer managed irrigation systems, can be defined as the engagement in *hybrid action* for the use, operation and maintenance of an irrigation system via a mix of individual and/or collective practices, and/or the engagement of external actors to ensure the functioning and sustainability of the system based on a local (hydraulic) identity, and/or formal and informal normative frameworks and ad-hoc practices. Below the three constitutive concepts or communality are further elaborated.

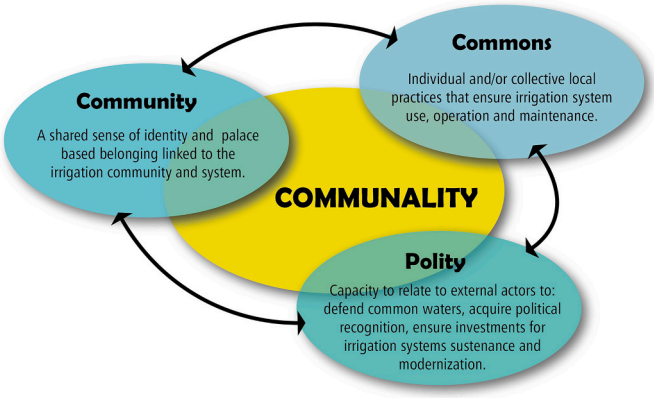


Fig. 1. Communality and its constituent elements commons, community, polity (own elaboration).

3.1. Commons

The commons can be defined as the natural resources, in this case water, together with the members of a community or group of users who manage and use this resource for collective and individual benefit. In user managed irrigation systems this concerns water flows and the water infrastructure through which these flows link the different users. The characteristics of this infrastructure and of the water availability often play a very important role in shaping how water as a common resource is managed (e.g. Ivars and Venot, 2018); and through which individual and/or collective practices and institutional arrangements.

In mountain or hill irrigation water availability is often constrained and high and continued investments need to be made to maintain, repair and operate the infrastructure. This is usually regulated by formal and informal normative frameworks which establish rights and duties (Aubriot, 2022; Hoogesteger, 2013b; Zwarteveen et al., 2005). Additionally an organization or institution (formal or informal) that takes charge of implementing and enforcing the norms is in place. Although formal rules, rights and positions are often present and formally arranged, in practice these tend to be malleable and in a constant process of transformation. In other systems such as those found in valley bottoms and floodplains, where infrastructures are often lighter and diffuse, institutional arrangements tend to be less structured and collective action often takes the form of loosely coordinated individual practices. But in most cases tasks that guarantee the continuity and longevity of irrigation systems may be divided into the following main categories (see also Boelens et al., 2015: 112–113; Boelens and Hoogendam, 2002):

- Tasks of operational water management: operation of hydraulic works to guide water flows through individual (often loosely coordinated) practices and/or through coordinated action based on a normative framework that establishes responsibilities such as scheduling, distribution and surveillance of water shifts to specific individuals within the irrigation community.
- Tasks of construction and maintenance of the infrastructure: design, construction, repair and modification of hydraulic works and the irrigation network through either individual or collective investments and practices; and sometimes through the engagement of external support.

In irrigation communities where collective action prevails as the basis for the above tasks the following are also essential (see Hoogesteger, 2013b):

- Tasks of internal organization: definition of objectives, decision-making, activities coordination and planning, monitoring of implementation, conflict resolution, and ensuring members' participation.
- Tasks of mobilizing and administering resources: of both the members and of external resources that are support irrigation communities; e.g. financial means, material resources, agricultural products, labor, and information.

The contents of these elements and the degree and form of collective action that is needed to sustain the hydrosocial irrigation system depends on its technical complexity, on the range of activities to be implemented, on the degree of specialization they require, on the number of users, and on the characteristics of 'external' socio-political, financial-economic and agro-climatological factors. Users engagement in water use, as well as in the tasks that are needed for it can be seen as a process of *commoning* that cannot be construed as a particular kind of entity, rather it is "an unstable and malleable social relation between a particular self-defined social group [irrigators] and those aspects of its actually existing or yet-to-be-created social and/or physical environment deemed crucial to its life and livelihood" (Harvey, 2012). This creates and recreates a social relation between and among the users (commoners) and the irrigation system and its water flows (a common). How these relations get shaped and reproduce within an irrigation community are extremely diverse; as Greslou (1989) observed, there are as many ways to allocate, manage and distribute water as there are 'types of water' and organizational levels, from the family level to the inter-family group, community, ethnic group.

3.2. Community

A community is usually considered as a social unit that is bound together by interdependence and shares some sort of identity. As many community irrigation studies show, this binding together does not imply bonds of intrinsic solidarity or social justice, nor narrowly bounded political-geographical or cultural systems (e.g. Hoogesteger, 2013b, Mirhanoğlu et al., 2022; Roth et al., 2015). Community identity can come from sources such as place identity, religion, values, culture, ethnic identity or other forms of identification and belonging. For the Andes, Boelens (2014) describes what he has termed as shared hydraulic identities in which water is the central element that binds a specific community together. Often different sources of identity and shared interests that unite people intermingle, intersect and interrelate with each other (Cárdenas and Ostrom, 2004). As such water users of an irrigation system can be bound to each other through ties and interdependencies that range from village or place bonds to shared ethnicity, professional background or political party. These intersecting identities are a constant source of unity and oftentimes also disputes or outright conflicts. This paradox of on the one side unity in the midst of internal disparity, has been termed 'agonistic unity' by Colloredo-Mansfeld (2009). Agonistic unity is conceptualized as the process of managing differences, negotiating disputes and constructing a common shared identity that enables communities to sustain themselves and mobilize the required resources to re-create the shared commons (Colloredo-Mansfeld, 2009; Verran and Christie, 2013). Through culturally specific forms of community re-creation people get involved in a variety of individual and collective practices, initiatives and activities through which they root and affirm themselves as constitutive of their community. Organization in whatever form there is, rather than being an end, constitutes a process and a means for water users collectives to manage and sustain, often through constant transformations, water use systems and community (Hoogesteger and Verzijl, 2015). In some communities, there are special roles and procedures for irrigation matters, whereas in others they are included in the overall grouping of other community issues (Hoogesteger, 2013a). Even in cases where communities make their own separation into water-related and non-water-related institutions, this often may be superficial. Because of this 'community embeddedness' of irrigation tasks, users often share a series of cognitive elements, which are the ideas and beliefs about how to cooperate and interact with each other in and around the use and management of water through particular 'water cultures' and 'hydraulic identities' (Boelens, 2014). However one cannot take these for granted nor see them as static and fixed. Different water cultures and related community evolve and change as a result of social, cultural, economic, technical, managerial and climatological transformations within which communities, irrigation systems and related water cultures are embedded.

3.3. Polity

We refer to polity here in terms of a political entity; that is a group of people or community that has the capacity to mobilize resources to advance their interests vis-à-vis state agencies and other external actors such as other user groups, non-governmental organizations, politicians, etc. We conceptualize polity building on the notion of *water collectives* (see Vos et al., 2020). The idea of water collectives is distinct from the influential conceptualization of Elinor Ostrom (e.g. Ostrom, 2007, 2009) that posit communal systems as relatively isolated from their institutional surroundings and not politically active outside the irrigation system they manage. Instead, the notion of "water collectives" puts to the fore the political nature of such organizations (see also Clement, 2010; Whaley, 2018).

Building on the notion of *grassroots scalar politics* (Hoogesteger and Verzijl, 2015) we propose to study *polity* of irrigation communities (a specific form of water collectives) by focusing on the strategies by which these pursue their interests through interactions and alliances with differently scaled (local, regional, national) actors and networks. Irrigation communities use different strategies to pursue their interests and defend their commons. These can be bundled in three distinct clusters of strategies which are: a) the consolidation of new scaled organizations that bundle several irrigation communities to defend the collective interests at broader scales; b) the creation of networks and alliances with external actors that have the capacity to support and/or materialize the demands of (some members of) the irrigation community; and c) the development of subversive strategies that can be visible such as street protests, boycotts and mediatic campaigns through which politicians and policy makers are put under pressure to listen to the collective's demands, or operate silently through lobby, personal contacts and other strategies. Through these strategies irrigation communities increase their ability to advance their interests and access financial and political support from state agencies (municipal, provincial, national), politicians and other actors. At the same time these strategies can increase the capacity of irrigators to gain a voice in decision making processes that concern their interests (Perreault, 2008; Perreault, 2014; Hoogesteger, 2016, 2017). The basis of most of these strategies is the creation of alliances. In doing so they regularly switch alliances and networks from those that cannot help them with a specific demand at hand, to those that have the capacities and power to do so. In this way political space is strategically sought and polity developed (Bebbington et al., 2010; Hoogesteger et al., 2017).

Irrigation communities' capacity to develop political agency at any given moment in time, does not only depend on their internal strength. Vos et al. (2020) identified five mayor contextual factors that influence irrigators communities' capacity to develop political agency: (1) the support or counterwork offered by the state bureaucracy, (2) support by the academic environment and societal water culture and ideas about the environment, (3) strength of the civil society and freedom of expression in the media, (4) the economic circumstances, and (5) the water, climate and agricultural technology context.

4. Analyzing the four case studies

In the section below we explore how different elements of communality work out and ensure irrigation system longevity based on four

case studies in very different contexts. In all systems infrastructure to guide water flows has been sustained and modernized over the past centuries.

4.1. The Acequia real del Júcar: Sustaining an ancient irrigation system through political strategizing

The irrigators community (*comunidad de regantes*)(IC) of the Acequia Real del Júcar (ARJ) brings together all the farmers who irrigate from a canal built in the 13th century by King Jaume I. Expanded in the 18th century, it covers 19,000 ha on the alluvial plain between the river Jucar and the coastal lagoon of L'Albufera, in the Valencia Region, east of Spain. The ARJ has been governed by the irrigators through well institutionalized collective action since its foundation, but with different degrees of involvement by external actors such as the crown or the municipalities. Since the end of the 19th century, the irrigators (landholders) have completely controlled the institution, through elected positions in 20 local boards and a general government board that brings these 20 together under the ARJ. The ARJ has played a pivotal role in ensuring sustained use, operation, maintenance and modernization of the irrigation system through the mobilization of collective action, which involved proactive political strategies of engagement with a multitude of actors (polity) – most notably the Spanish government.

Based on a strong institutional foundation of organized irrigators, the main challenge for the ARJ has always been to defend their water allocation from the Jucar River vis-à-vis other (new) water users. Coexistence with other river users has led to confrontations and the elaboration of alliances and political strategies such as the creation of the *Sindicato de las Siete Acequias del Júcar* in 1866, which played a pivotal role in preventing the expansion of irrigation in the upper basin and to stop the plans for inter-basin water transfers to the neighboring province of Alicante (Calatayud, 1988a, 1988b).

In the early 1930s, a company obtained a State concession to build and manage a large reservoir in Alarcón, in the upper basin of the Jucar river. This meant leaving the regulation of the river in the hands of a private company. The ARJ firmly opposed this initiative and again mobilized the irrigators of the lower basin to confront the national policy. They requested from the Ministry of Public Works the creation of a river basin authority (RBA) controlled by both the irrigators and the hydropower companies already active in the basin. This was done to curb the aspirations of new users and to guide the construction and management of reservoirs in the Júcar basin. The approval decree of the RBA (*Confederación Hidrográfica del Júcar*) took place in November 1934, when a former ARJ lawyer was president the Spanish Republic (Mateu, 2011). The irrigators of the lower Júcar had a majority representation in the RBA assembly, 30 delegates out of 52 (D'Amaro, 2012). Throughout the Franco dictatorship (1939–1975), the political apparatus attempted to outlaw the Spanish ICs. The ARJ headed the resistance of these plans by organizing semi-clandestine meetings, creating a national federation (FENACORE), fighting dissolution orders in court, and putting in place political levers to ensure their survival (D'Amaro, 2022).

Under the Franco regime, the ARJ also promoted and financed the construction of the Alarcón reservoir, the only large dam (1112 Mm^3) fully paid by farmers in Spain. They created the association USUJ (*Unidad Sindical de Usuarios del Júcar*), together with five other ICs of the Lower Jucar and a hydropower company, in order to defend their common interests once the RBA lost its participatory organs and was placed under the strict control of state engineers (Carles-Genovés et al., 2007).

The development of new irrigation systems in the upper reaches of the Jucar Watershed (in the La Mancha region) (100,000 ha) since the 1980s reduced the water availability in the lower Jucar River. This led to tensions between the two regions. These were partially resolved in 2001 with the signing of the so-called Alarcón Agreement in which USUJ ceded the ownership and management of the Alarcón reservoir to the State (Sanchis-Ibor et al., 2019). In exchange, the State guaranteed them the historical priority of water use; gave them a 60-year exemption on dam maintenance costs; and assumed the complete financing of the modernization of the irrigation system towards drip irrigation.

The adoption of drip irrigation started to change the hydraulic infrastructure of the ARJ in 2006. This led to important changes in its internal organization. The design, installation and later also the maintenance of drip irrigation networks was implemented by private companies, which designed drip irrigation networks according to standardized models, not adapted to local necessities. This generated numerous technical and maintenance problems, which increased the management costs. New technical personnel was hired by ARJ to operate the drip irrigation systems, and this technical staff progressively introduced changes in the infrastructure of drip irrigation systems, adapting it to the local conditions and reducing operational costs (Ortega-Reig et al., 2017a, 2017b; Poblador et al., 2021). In this process, technicians (usually hydraulic engineers) have centralized management by gradually replacing the traditional local ditch tenders.

Changes in irrigation practices came alongside political engagement (Carles-Genovés et al., 2007; García-Mollá et al., 2013). To defend their 'traditional water allocation', during the first two decades of the 21th century, the ARJ fiercely opposed the Júcar-Vinalopó water transfer (Ferrer et al., 2006). USUJ, together with other environmental organizations and left-wing parties, mobilized against this transfer through street protests, political strategizing and mediatic campaigns. Their efforts and political agency were such that during the socialist Zapatero government the plans for the transfer were transformed by moving the intake of the water transfer to the Jucar river mouth at the Mediterranean Sea.

4.2. Smallholder irrigation in the Ecuadorian highlands: Strong collective action, community grounding and alliance building

According to FAO (2010) the estimated irrigated area in Ecuador is 1,500,000 ha out of which 466,000 ha, most of which are concentrated in the Highlands, are managed by irrigation communities. Most irrigation schemes are small and cover areas of up to a few hundred hectares on the hilly slopes. Larger (formerly) state managed schemes, with a command area of between a couple of hundred hectares and up to 10,000 ha also dot the landscape, many of which are in the inter-Andean valleys that interrupt this rugged terrain (Hoogesteger, 2013a, 2013b). Water flow patterns, physical irrigation infrastructure and management practices are locally defined and vary from irrigation system to irrigation system. In the last thirty years an increasing number of irrigation systems have been modernized with the support of external (state or NGO) technical and financial support. Modernization usually implies that irrigation canals have been lined with cement structures or tubes, night storage reservoirs have been built and some irrigation systems have been pressurized (through gravity) to enable sprinkler and -in some scattered cases- drip irrigation (Hoogesteger, 2013b, 2015). Water allocation and distribution, canal construction and maintenance and the resolution of conflicts are mostly managed at the village level (Manosalvas et al., 2021) and in systems that compromise several villages within the irrigation community (Hoogesteger, 2013a). Most irrigation communities are formally institutionalized and recognized by state agencies.

Before the 1900s, many of the smaller irrigation schemes were built, taken into use, and dominated by landlords (or *haciendas*) who gave water to peasants in exchange for labour. A minority were built and/or maintained by 'free communities'. During the agrarian reforms of the 1960s and 1970s, many villages acquired land[1] formerly owned by hacienda and, with it, often also the irrigation systems and related water

[1] The Ecuadorian agrarian reforms are very much debated as most *haciendas* were able to keep their most productive land (often irrigated land) while communities were given the marginal lands.

allocations (Janvry and Sadoulet, 1989). Where the technical possibilities existed, villages engaged at supra-community level in struggles for obtaining irrigation water through either the rehabilitation of formerly hacienda owned irrigation systems or the construction of new ones (often financed by external agents and the state) (Boelens and Hoogendam, 2002; Boelens and Hoogesteger, 2017).

Grounded in a strong tradition of village organization and ethnic identity struggles, most irrigation systems have built-on, and strengthen community through strategies of organization and control that include the establishment of local councils and general assemblies for decision making, lists for tracking participation, contributions and investments in communal efforts and marking jurisdictional lines (Manosalvas et al., 2021). These strategies have been termed ' vernacular statecraft' by Colloredo-Mansfeld (2009) and are expressed in irrigation management as systems of water rights. Intrinsic to these water rights is the mobilization of collective labour and other resources for the communal benefit (*mingas*). *Mingas* are compulsory for community members and are coordinated by community leaders and community assemblies.

How water rights and the mobilization of collective action takes place in each irrigation system varies greatly, not only from region to region and from one irrigation system to another; but also in time. In many irrigation systems where large commercial producers share the waters with smallholders, there tends to be a constant struggle for the control of both the water resources as well as the decision-making within the confines of the irrigation communities (Mena-Vásconez et al., 2016; Hoogesteger et al., 2017). These struggles usually intensify in dryer periods of the year, or when new crops and water demands change and challenge the existing water rights systems.

At broader scales, irrigation communities are often well connected in federations through which they defend their interests vis-à-vis state agencies. The indigenous movement has been an important channel through which irrigation communities have developed political agency in the water domain at provincial and national level. Through the National Confederation of Indigenous Peoples (CONAIE), which put water high on its political agenda, many water related concerns have been addressed (Boelens et al., 2015). In two provinces irrigation community federations developed in the early 2000s (Hoogesteger, 2012) and at national level a multistakeholder network of state agencies, NGOs and irrigation communities, the Water Resources Forum, was created (Hoogesteger, 2016; Goodwin, 2019). Through these federations and networks, recognition and autonomy of irrigation communities has been defended, investments in community irrigation development have been put high on the political agenda, and spaces for dialogue and co-decision making have been continuously sought (Hoogesteger, 2017; Dupuits, 2019; Dupuits et al., 2020). These same networks are an important resource for irrigation communities to find NGOs and state agencies' support for the modernization or repair of their irrigation systems.

4.3. The Cambodian Preks: Sustaining irrigation in a context of water abundance

Most village names in the mosaic landscape of the Cambodian Upper Mekong delta start with the word *prek*, a term that means "connection" in Khmer and is also used to designate the many earthen canals that crisscross the floodplain. *Preks* connect the main rivers, the Mekong and the Bassac, with their adjacent floodplain, which remains under water for several months a year and are otherwise intensively cultivated (Venot and Jensen, 2022). They date back to the late 19th century when local community chiefs - later supported by the colonial authorities (Barthelemy, 1915)- dug breaches across the river levees. As flood waters entered through these breaches, in the process increasing their width, so did sediments that deposited in the floodplain. This progressively raised land and extended the area that could be cultivated: fields are slightly more elevated than the bed of the *preks*, whose hydrology is tuned to river water levels. Today, more than 200 *preks,* spaced 500 m to 1 km apart along the Bassac and the Mekong rivers, structure one of the most intensively cultivated landscape of Cambodia. Pumping water that flows through the *preks* with small diesel pumps, thousands of smallholders irrigate fruit trees and vegetables close to the river banks in fields that are seldom flooded and are known as *Chamkar*. Smallholders also produce rice in the low-lying areas that are flooded part of the year and are known as *boeungs*. Local communities long organized themselves around the management of water flowing through the *preks* Land tenure systems were for instance designed with a view towards equity in relation to the opportunities water flows and sedimentation dynamics provided (Siri, 1998), with smallholders being allocated long and narrow stretches of land perpendicular to the *preks* in the *Chamkar* and square fields in the *Boeung*. When the flood rose, irrigators collectively built a temporary earthen dam at the tail end of the *prek* they used, where it merged in the *boeung*, so that they could harvest their crops. This was done under the authority of a *prek* chief (*mèprek*) and several adjacent communities, using adjacent *preks*, sometimes came together hence building a dam that would not only protect crops from the water coming via the *preks* but also through the floodplain itself.

Preks have always had a key role in the local social fabric but their management has evolved significantly over time, especially in the last two decades. *Preks* are now mostly envisioned and have been redesigned with the view to intensify dry season cultivation through increased water control. This has imperilled other uses and services such as transport, sedimentation, fish population regeneration and flood mitigation (JICA, 1998; SOFRECO, 2018), that are central to local identities and practices. The most visible aspect of these changes relates to the deep excavation of *preks* that had progressively silted up and to the construction of concrete sluice gates at their entrance, close to the main rivers in the framework of externally funded development projects. In a context of delayed flood peaks due to increase upstream water control along the Mekong, these sluice gates are meant to store water for dry season cultivation but are, above all, devices to establish the ruling party as Cambodia's caretaker (Venot and Jensen, 2022).

Infrastructural changes have come hand-in-hand with technocratic institutional reforms centred on the establishment of "Prek User Communities" following the model of Water User Associations (Ivars and Venot, 2018). But the existing infrastructure affords little opportunity for collective action in a context where individual access to irrigation is the norm, and there are also few incentives for it as Prek User Communities are mostly geared at levying fees for infrastructure maintenance. The irrigation "communities" have, nonetheless, become a largely bureaucratic and artificial construct. There hasn't been any attempt at structuring them at a larger scale though they are meant to oversee the management of adjacent and interlinked *preks*.

In today's *prek* system, irrigation-related collective action remains limited and the continued existence of the *preks* may rather have its roots in a strong sense of (place) belonging, as village names indicate. Another important element is a particular form of polity that hinges on the silent (at least for the foreign researcher) activation of highly politicized clientelist and patronage networks that ensure investments in irrigation and other sectors by external actors.

4.4. Mountain irrigation in Tsangano, Mozambique: Building on local collective action and networks

Diversions from mountain streams into earthen canals through temporary diversion structures made of sandbags, logs, grass and soil have a long history in East and Southern Africa, in some places dating back from before colonial times (Adams, 1990; Bolding, 2004). This type of irrigation has been referred to as furrow irrigation, whereby furrow refers to the earthen main canal rather than a field water application method. In Mozambique this type of mountain irrigation likely goes back to the early 20th century and expanded with colonial development. Quick expansion to larger irrigated areas only happened after the end of the civil war, from 1992 onwards (Beekman et al., 2014).

Characteristically, several irrigation systems take water from one

stream, sometimes additionally capturing water from side streams, springs or neighboring catchments. These systems are interlinked, whether indirectly through seepage and excess water losses reverting to the river to be used downstream or through direct interlinking of several furrow systems. These demonstrate a picture of a hydrologically interconnected water network (Van der Zaag et al., 2010), rather than a series of discrete irrigation systems. Periods of droughts or of above average rainfall, often occurring in cycles of several years, lead to shrinkage and growth of irrigated area. Apart from responses to climatic variations, farmers dynamically reconfigure furrow irrigation practices in response to changing demographic, political and market conditions, physically changing the canals in time and space.

Tsangano District in the North-East of Tete Province, bordering on Malawi, is an example of an area where the development of furrow irrigation systems has quickly grown over a large area. Compared to other hill furrow irrigation systems, those on the Tsangano plateau are exceptional in their size, with some furrows irrigating command areas in excess of 200 ha with over 100 members. The types of irrigation systems that emerge in such an environment are varied and integrated with their sociocultural contexts and can take three main organizational forms, namely the *former Portuguese systems*, *communal systems* and *family systems* (Nkoka et al., 2014).

The cases presented in Nkoka et al. (2014) each show that the establishment history and interlinking with wider sociocultural community structures of these systems exerts an important influence on current water distribution practices and water governance in general.

Communal irrigation systems heavily depended on knowledge that was brought in by the Portuguese settlers or supplanted private colonial irrigation systems. Regarding furrow systems in Manica province, show that water rights are not only based on investments in infrastructure but that they are often established through a mixture of investment, customs and social networks while they are reproduced through the fulfilment of obligations of which maintenance of infrastructure is only one aspect. In the *communal systems* of Tsangano this led to a management structure in which elders lay claims of hydraulic property on parts of the system. They strategically use their authoritative positions to maintain those rights. The other users participate in maintenance, but only gain use rights, not control rights. There is some free-riding tendency, but often it is penalized through exclusion from access to water.

Family irrigation systems are enterprises under the control of a single patriarch, which does not mean that other (non-family) irrigators are fully excluded. Creators of *family systems* succeed in structurally excluding landowners who are located upstream of their own plots. Owners exert authority through a social or patronage network developed through marriages. In this way *family irrigation systems* are part of the social fabric of the community. As the ownership of these systems is more exclusively claimed than in the other types of systems, participation in the construction and maintenance of the system is a more contested domain. The owners openly try to limit other irrigators from interacting with the irrigation infrastructure in order to fortify their exclusive ownership. Through involving family members in maintenance and management, patriarchs affirm the family ownership of the property.

For the *former Portuguese systems* the original colonial investor/constructor is no longer there and governance of the system has taken shape depending on how the system was appropriated by its new users. Some are being operated on a 'state company model' introduced upon nationalization following independence, where *capitães* (captains) each operate their own section. Often, these are sons or relations of the previous state company *capitães*. Where government intervention is completely absent in the *communal* and *family irrigation systems*, here it interfered by establishing an *irrigation chief*, though most of the decisions are actually made by the *irrigation elders*, who are closely integrated in the community authority structures. The tendency to try to free-ride on maintenance obligations seems to be a continuation of labour practices that were common on state and collective farms: nobody really felt responsible. In *former Portuguese systems*, only those people who aspire to take on authority pro-actively engage in maintenance activities and free-riding by others seems to be routinely accepted.

The three types of irrigation systems each display different hydraulic property regimes, related to their investment histories as well as to the way in which they are integrated into the sociocultural fabric of the communities. Investment in construction and maintenance alone is not enough to guarantee authority and control. One needs supporting social networks, which are actively built and maintained with reference to other forms of authority, e.g. links to traditional authority, economic power and seniority. Kin relations play a particularly important role in the enforcing and transferring of hydraulic property claims.

These different furrow irrigation systems have not organized at higher levels and their interactions with state agencies is very limited; especially as many are considered illegal. In this sense, these systems have been sustained by and large through local collective action and community and as such fall under what Woodhouse et al. (2017) have termed Farmer Led Irrigation Development; defined as: "a process whereby farmers drive the establishment, improvement, and/or expansion of irrigated agriculture…" (Veldwisch et al., 2019:2).

5. Comparing the four cases through the lens of communality

In this contribution we have set out the conceptualization of *communality* by bringing together the notions of commons, community and polity in relation to user managed irrigation system sustenance. Comparative analysis of the four studied cases is presented in Table 1 and represented in Fig. 2.

The comparison of the four cases above shows that there are great differences in how and through which mechanisms the irrigation systems are sustained. The ARJ shows how the irrigation system has been sustained through a highly institutionalized commons in which collective action is coordinated by a well-established organization (the ARJ) in which most of the operation and maintenance tasks are carried out by hired technicians and personnel in a context of weakening community ties. It also shows that the irrigation community has over the last two centuries sustained a high level of polity in order to defend their organization and its historical water allocation in a basin with increased water competition.

Irrigation communities in the Ecuadorian highlands show high levels of commons, community and polity. Local organizations and institutions which are often strongly linked to village affairs, institutions and identities (most notably place based village belonging, peasant and indigenous identities) play an important role in mobilizing collective action for irrigation system operation and maintenance, as well as for the development of polity through networking, political pressure, street protests and mobilizations. Through polity many irrigation communities have received support for the construction, modernization and maintenance of their irrigation systems and have participated in a longstanding struggle for recognition and a voice in decision making in broader water governance affairs.

The preks in Cambodia show low levels of commons and high levels of community while polity hinges on the activation of highly politicized clientelist and patronage networks. A possible explanation for the low levels of commons is the hydraulic characteristics of the system which functions above all through individual practices (pumping) and while requiring relatively little collective operation and maintenance to function. This in spite of a strong place based identity in and among the irrigators.

In Tzangano, Mozambique irrigation communities show some differences but all have a strong sense of community. Sustenance of irrigation systems is done through different mixes of individual and collective practices that are coordinated and controlled through distinct institutions (family, village leaders, capitaes). All share low levels of polity as the functioning of the irrigation networks depends on staying 'invisible' from State institutions.

Table 1
Comparing the four analyzed cases through communality.

Case study	Commons	Community	Polity
Acequia Real del Júcar, Spain	- Commons threatened by competing water claims in basin. - Collective action for system operation and maintenance mobilized by the formal organization (ARJ) of the irrigation community mostly in the form of hired technical staff. - Normative framework highly institutionalized/ bureaucratized in Irrigation Community already for centuries.	- Nested structure of local village irrigation boards. - Strong place identity.	- Long history of political mobilization and engagement. - Strong linkages and political agency with/in government agencies at different scales. - Strong linkages with neighboring IC's through USUJ. - Strong national presence in FENACORE.
Smallholder irrigation in the Ecuadorian Highlands	- Long history of struggles to acquire land and water. - Collective water rights per IC - Well established normative frameworks (water rights) and often related organizations. - Infrastructure sustained and managed through collective action (*mingas*). - Level of institutionalization dependent on size of IC.	- Strong linkages IC with communities. - Water & irrigation often part of village affairs. - Strong place based identity with village and ICs. - Strong linkages with indigenous, peasant and sometimes religious identities.	- Often well connected to other ICs through provincial federations or the indigenous movement. - Able to mobilize technical support from NGOs and State agencies. - Great capacity for mobilizations and street protests.
Preks, Cambodia	- Commons threatened by individualization of water access and increased agricultural differentiation. - Bureaucratic, externally, enforced, organizational form of participation and management - Irrigation infrastructure affording little scope for regular/frequent collective action	- Strong place based identity and sense of belonging - Prek as structuring element of social life	- Activation of politicized patronage networks - No nested institutional organizational forms
Mountain irrigation in Tsangano, Mozambique	- Access to land and water within systems strongly depends on hydraulic property relations, moderated by original investments and recurrent labour contributions for system maintenance. - In family systems, the original patriarch denies newcomers from contributing to maintenance, so as to withhold them from a claim on a share of the water.	- Strong role for traditional village leaders in irrigation governance - In former Portuguese systems the community is formed by descendants of former labour force, including the foremen (capitaes) that have a strong sense of shared identity. - Irrigation leaders' authority also links to outside the irrigation system, to traditional authority, economic power and seniority.	- No connections, networks and alliances or protests above the level of single irrigation systems. Rather the continued functioning of the irrigation networks depends on staying 'invisible' from State institutions.

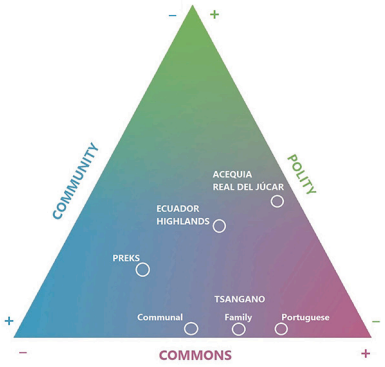


Fig. 2. Comparing the four cases in the framework of communality (own elaboration).

6. Conclusions: Going beyond collective action through communality

The analysis of the four case studies through the notion of communality shows that irrigation system sustenance does not hinge on collective action alone. It confirms that irrigation systems sustenance rather rests on hybrid action which consists of a mix of individual practices, collective practices, and/or the engagement of external actors to ensure the functioning and sustainability of the system. Our analysis shows that communality offers a valuable entry point to analyze and better understand farmer managed irrigation systems sustenance in new ways that go beyond the traditional institutional analysis. First it focuses on hybrid action which importantly recognizes individual practices and external interventions as well as collective action as mechanisms that sustain irrigation systems. This opens up the analysis not only to formal and informal normative frameworks and irrigation organizations, but also to individual action, patronage and clientelist systems, family ties and the importance of local (hydraulic) identity within irrigation communities. The notion of polity brings in the analysis of the political multi-scalar relations and strategies through which irrigation communities engage with external actors to defend their water allocations, infrastructure and organizations vis-à-vis upcoming threats and/or to fulfill internal needs such as investments or technical expertise. These insights open new lines of inquiry into how and through which mechanisms irrigation systems are sustained by irrigation communities. It also invites for a renewed power and politics sensitive conceptualization of common pool resource management (see Clement, 2010; Whaley, 2018). At the same time we consider that the notion of communality has great potential to be enriched and expanded beyond its current conceptualization importantly linking it to more quantitative research approaches and its relations with technological, infrastructural, productive, agronomical, economic and climatological factors that interact with the above analyzed dimensions of communality. In doing so it can become a tool to further explore the very different and diverse ways through which irrigators are able to sustain their irrigation systems amidst a constantly changing context.

Declaration of Competing Interest

The authors declare to have no conflicts of interest related to the data used for this manuscript nor with the concepts and ideas that are expressed in it.

Data availability

All data used can be provided on request and has been referred to.

References

Abdullaev, I., Mollinga, P.P., 2010. The socio-technical aspects of water management: emerging trends at grass roots level in Uzbekistan. Water 2 (1), 85–100.

Adams, W.M., 1990. How beautiful is small? Scale, control and success in Kenyan irrigation. World Dev. 18 (10), 1309–1323.

Agrawal, A, Gibson, C.C., 2001. Communities and the environment: ethnicity, gender, and the state in community-based conservation. Rutgers University Press.

Araral Jr., E., 2009. What explains collective action in the commons? Theory and evidence from the Philippines. World Dev. 37 (3), 687–697. Retrieved from. http://www.scopus.com/inward/record.url?eid=2-s2.0-59649097448&partnerID=40&md5=e0ab7cee5069e7a11647b4ec25736eed.

Aubriot, O., 2022. The history and politics of communal irrigation: a review. Water Alternatives 15 (2), 307–340.

Bardhan, P., 2000. Irrigation and cooperation: an empirical analysis of 48 irrigation communities in South India. Econ. Dev. Cult. Chang. 48 (4), 847–865.

Barthelemy, R., 1915. Premières Etudes des colmatages du Mékong. Archives Nationales du Cambodge, Résidence Supèrieure, Phnom Penh.

Baumann, M.D., 2022. Examining land rental market's linkages to land and water control in Colombia's irrigation megaprojects: integrating the political economy of agrarian change and the political ecology of vulnerability. J. Peasant Stud. 1–27.

Bebbington, A., Humphreys Bebbington, D., Bury, J., 2010. Federating and defending: Water, territory and extraction in the Andes. In: Boelens, R., Getches, D., Guevara-Gil, A. (Eds.), Out of the Mainstream: Water Rights, Politics and Identity. Earthscan, London, Washington D.C., pp. 307–327

Beekman, W., Veldwisch, G.J., Bolding, A., 2014. Identifying the potential for irrigation development in Mozambique: capitalizing on the drivers behind farmer-led irrigation expansion. Physics and Chemistry of the Earth, Parts A/B/C 76, 54–63.

Berthet, E.T., Hickey, G.M., 2018. Organizing collective innovation in support of sustainable agro-ecosystems: the role of network management. Agric. Syst. 165, 44–54.

Boelens, R., 2014. Cultural politics and the hydrosocial cycle: water, power and identity in the Andean highlands. Geoforum 57, 234–247. https://doi.org/10.1016/j.geoforum.2013.02.008.

Boelens, R., Hoogendam, P. (Eds.), 2002. Water Rights and Empowerment. Van Gorcum, Assen.

Boelens, R., Hoogesteger, J., 2017. Collective action, community and the peasant economy in Andean highland water control. In: Water Governance and Collective Action. Routledge, pp. 96–107.

Boelens, Rutgerd, Seemann, M., 2014. Forced engagements: Water security and local rights formalization in Yanque, Colca Valley, Peru. Hum. Organ. 73 (1), 1–12.

Boelens, R., Vos, J., 2014. Legal pluralism, hydraulic property creation and sustainability: the materialized nature of water rights in user-managed systems. Curr. Opin. Environ. Sustain. 11, 55–62. https://doi.org/10.1016/j.cosust.2014.10.001.

Boelens, R., Hoogesteger, J., Baud, M., 2015. Water reform governmentality in Ecuador: neoliberalism, centralization, and the restraining of polycentric authority and community rule-making. Geoforum 64, 281–291. https://doi.org/10.1016/j.geoforum.2013.07.005.

Bolding, J.A., 2004. In Hot Water. A Study on Sociotechnical Intervention Models and Practices of Water Use in Smallholder Agriculture, Nyanyadzi Catchment, Zimbabwe. Ponsen & Looijen.

Bolding, A., Mollinga, P.P., van Straaten, K., 1995. Modules for modernisation: colonial irrigation in India and the technological dimension of agrarian change. The Journal for Development Studies 31 (6), 805–844.

Calatayud, S., 1988a. Notas sobre la administración de las aguas para el riego en la Ribera del Xúquer (1850-1900). In: L'escenari historic del Xuquer: actes de la IV Assemblea d'Història de la Ribera. Ajuntament de l'Alcúdia, Alcudia, pp. 157–166.

Calatayud, S., 1988b. Límits i transformacions del sistema de reg a la Ribera del Xúquer durant el segle XIX. In: Actes de la V Assemblea d'Història de la Ribera. Ajuntament d'Almussafes, Almussafes, pp. 315–328.

Cárdenas, J.-C., Ostrom, E., 2004. What do people bring into the game? Experiments in the field about cooperation in the commons. Agric. Syst. 82 (3), 307–326. https://doi.org/10.1016/j.agsy.2004.07.008.

Carles-Genovés, J., García-Mollà, M., Sanchis-Ibor, C., Vega-Carrero, V., Avellà-Reus, L., 2007. Case studies synthesis, Spain—institutional framework for local irrigation Management in Spain: the case of upper Genil and low Jucar valleys. Available online. http://www.isiimm.agropolis.org/OSIRIS/report/Isiimm-SynthesisSpain_eng.pdf.

Clark, A., Holland, C., Katz, J., Peace, S., 2009. Learning to see: lessons from a participatory observation research project in public spaces. Int. J. Soc. Res. Methodol. 12 (4), 345–360.

Clement, F., 2010. Analysing decentralised natural resource governance: proposition for a "politicised" institutional analysis and development framework. Policy. Sci. 43, 129–156.

Collins Dictionary, 2022. https://www.collinsdictionary.com/ (accessed 01-09-2022).

Colloredo-Mansfeld, R., 2009. Fighting like a community. In: Fighting like a Community. University of Chicago Press.

D'Amaro, F., 2012. En defensa de la Acequia Real. Los regantes del Júcar ante la intervención estatal (1934-1964). Cuadernos de Geografía 91-92, 57–72.

D'Amaro, F., 2022. Antipatriotas del Agua. Conflictos y grupos de interés en el franquismo, Granada: Comares.

Dupuits, E., 2019. Water community networks and the appropriation of neoliberal practices. Ecol. Soc. 24 (2).

Dupuits, E., Baud, M., Boelens, R., De Castro, F., Hogenboom, B., 2020. Scaling up but losing out? Water commons' dilemmas between transnational movements and grassroots struggles in Latin America. Ecol. Econ. 172, 106625.

Esteva, G., 2014. Commoning in the new society. Community Development Journal 49 (suppl_1) (i144-i159.de).

FAO, 2010. aquastat. https://www.fao.org/aquastat/en/.

Ferrer, G., Estevan, A., La Roca, F., 2006. El conflicto del trasvase Júcar-Vinalopó. Bakeaz/Fundación Nueva Cultura del Agua, Bilbao (168 pp).

García-Mollá, M., Sanchis-Ibor, C., Ortega-Reig, M., Avellá-Reus, L., 2013. Irrigation associations coping with drought: The case of four irrigation districts in eastern Spain. In: Drought in Arid and Semi-Arid Regions. Springer, Netherlands, pp. 101–122.

García-Mollá, M., Ortega-Reig, M., Boelens, R., Sanchis-Ibor, C., 2020. Hybridizing the commons. Privatizing and outsourcing collective irrigation management after technological change in Spain. World Dev. 132, 104983.

Goodwin, G., 2019. The problem and promise of coproduction: Politics, history, and autonomy. World Dev. 122, 501–513. https://doi.org/10.1016/j.worlddev.2019.06.007.

Greslou, F., 1989. Visión Andina y usos campesinos del agua. PRATEC, Lima.

Harvey, D., 2012. Rebel Cities : From the Right to the City to the Urban Revolution. Verso, New York, p. 73 (ISBN 978–1–84467-882-2. OCLC 767564397).

Hommes, Lena, Hoogesteger, Jaime, Boelens, Rutgerd, 2022. (Re)making hydrosocial territories: Materializing and contesting imaginaries and subjectivities through hydraulic infrastructure. Political Geograph. 97, 102698. https://doi.org/10.1016/j.polgeo.2022.102698.

Hoogesteger, J., 2012. Democratizing water governance from the grassroots: the development of Interjuntas-Chimborazo in the Ecuadorian Andes. Hum. Organ. 71 (1), 76–86. https://doi.org/10.17730/humo.71.1.b8v77j0321u28863.

Hoogesteger, J., 2013a. Movements against the Current: Scale and Social Capital in peasants' Struggles for Water in the Ecuadorian Highlands. PhD. Wageningen University, Wageningen.

Hoogesteger, J., 2013b. Trans-forming social capital around water: water user organizations, water rights, and nongovernmental organizations in Cangahua, the Ecuadorian Andes. Soc. Nat. Resour. 26 (1), 60–74. https://doi.org/10.1080/08941920.2012.689933.

Hoogesteger, J. (2015). Normative structures, collaboration and conflict in irrigation; a case study of the Pillaro North Canal irrigation system, Ecuadorian highlands. Int. J. Commons, 9(1), 398–415. http://www.thecommonsjournal.org/index.php/ijc/article/view/521.

Hoogesteger, J., 2016. NGOs and the democratization of Ecuadorian water governance: insights from the multi-stakeholder platform el Foro de los Recursos Hídricos. Voluntas 27 (1), 166–186. https://doi.org/10.1007/s11266-015-9559-1.

Hoogesteger, J., 2017. The politics of water democracy: insights from grassroot struggles in the Ecuadorian highlands. Asia Pac. Viewp. 58 (1), 74–85. https://doi.org/10.1111/apv.12141.

Hoogesteger, J., Rivara, F., 2021. The end of the rural/urban divide? Migration, proletarianization, differentiation and peasant production in an Ejido, Central Mexico. J. Agrar. Chang. 21 (2), 332–355.

Hoogesteger, J., Verzijl, A., 2015. Grassroots scalar politics: insights from peasant water struggles in the Ecuadorian and Peruvian Andes. Geoforum 62, 13–23. https://doi.org/10.1016/j.geoforum.2015.03.013.

Hoogesteger, J., Tiaguaro-Rea, Y., Rap, E., Hidalgo, J.P., 2017. Scalar politics in sectoral reforms: negotiating the implementation of water policies in Ecuador (1990–2008). World Dev. 98, 300–309. https://doi.org/10.1016/j.worlddev.2017.04.036.

Ivars, B., Venot, J.P., 2018. Entre politiques publiques et matérialité : associations d'usagers et infrastructures d'irrigation au Cambodge. Natures Sciences Sociétés 26 (4), 383–394.

Janvry, A., Sadoulet, E., 1989. A study in resistance to institutional change: the lost game of Latin American land reform. World Dev. 17 (9), 1397–1407.

Japan International Cooperation Agency (JICA), 1998. The Agricultural Development Study of the Mekong Flooded Area in Cambodia-Final Report. Sanyu Consultant, Japan.

Manosalvas, R., Hoogesteger, J., Boelens, R., 2021. Contractual reciprocity and the re-making of community hydrosocial territories: the case of La Chimba in the Ecuadorian páramos. Water 13 (11), 1600.

Mateu, J., 2011. La primera Confederación Hidrográfica del Júcar. València: Ministerio del Medio Ambiente. Medio Rural, y Marino.

Meinzen-Dick, R., DiGregorio, M., McCarthy, N., 2004. Methods for studying collective action in rural development. Agric. Syst. 82 (3), 197–214.

Mena-Vásconez, P., Boelens, R., Vos, J., 2016. Food or flowers? Contested transformations of community food security and water use priorities under new legal and market regimes in Ecuador's highlands. J. Rural. Stud. 44, 227–238. https://doi.org/10.1016/j.jrurstud.2016.02.011.

Mirhanoğlu, A., Loopmans, M., Özerol, G., 2022. Social head-enders: access and Authority in Irrigation Governance. Soc. Nat. Resour. 35 (2), 185–203.

Misquitta, K., Birkenholtz, T., 2021. Drip irrigation as a socio-technical configuration: policy design and technological choice in Western India. Water Int. 46 (1), 112–129.

Mollinga, P.P., 2013. Canal irrigation and the hydrosocial cycle. The morphogenesis of contested water control in the Tungabhadra left Bank Canal, South India. Geoforum. 57, 192–204.

Mushtaq, S., Dawe, D., Lin, H., Moya, P., 2007. An assessment of collective action for pond management in Zhanghe irrigation system (ZIS), China. Agricultural Systems 92 (1–3), 140–156.

Nkoka, F., Veldwisch, G.J.A., Bolding, J.A., 2014. Organisational modalities of farmer-led irrigation development in Tsangano District, Mozambique. Water Alternatives 7 (2), 414–433.

Ortega-Reig, M., Sanchis-Ibor, C., García-Mollá, M., 2017a. Drip irrigation in eastern Spain. Diverging goals in a converging process. In: Venot, J.P., Kuper, M., Zwarteveen, M. (Eds.), Drip Irrigation: Untold Stories of Efficiency, Innovation & Development. Earthscan/Routledge, London.

Ortega-Reig, M., Sanchis-Ibor, C., Palau-Salvador, G., García-Mollá, M., Avellá-Reus, L., 2017b. Institutional and management implications of drip irrigation introduction in collective irrigation systems in Spain. Agric. Water Manag. 187, 164–172.

Ostrom, E., 1990. Governing the Commons: The Evolution of Institutions for Collective Action. Cambridge University Press, Cambridge.

Ostrom, E., 2007. A diagnostic approach for going beyond panaceas. Proc. Natl. Acad. Sci. U. S. A. 104 (39), 15181–15187.

Ostrom, E., 2009. A general framework for analyzing sustainability of social-ecological systems. Science 325 (5939), 419–422.

Paerregaard, K., 2018. Power in/of/as water: Revisiting the hydrologic cycle in the Peruvian Andes. Wiley Interdisciplinary Reviews: Water 5 (2), e1270.

Perreault, T., 2008. Custom and contradiction: rural water governance and the politics of usos y costumbres in Bolivia's irrigators' movement. Ann. Assoc. Am. Geogr. 98 (4), 834–854.

Perreault, T., 2014. What kind of governance for what kind of equity? Towards a theorization of justice in water governance. Water International 39 (2), 233–245.

Poblador, N., Sanchis Ibor, C., Kuper, M., 2021. The landing of parachuted technology, appropriation of centralised drip irrigation systems by irrigation communities in the region of Valencia (Spain). Water Alternatives 14, 228–247.

Poteete, A.R., Ostrom, E., 2004. In pursuit of comparable concepts and data about collective action. Agric. Syst. 82 (3), 215–232.

Poussin, J.-C., Diallo, Y., Legoupil, J.-C., 2006. Improved collective decision-making in action for irrigated rice farmers in the Senegal River valley. Agric. Syst. 89 (2–3), 299–323.

Reyes-Escate, Luis, Hoogesteger, Jaime, Boelens, Rutgerd, 2022. Water assemblages in hydrosocial territories: Connecting place, space, and time through the cultural-material signification of water in coastal Peru. Geoforum 135, 61–70. https://doi.org/10.1016/j.geoforum.2022.07.005.

Roth, D., 2011. The subak in diaspora: Balinese farmers and the subak in South Sulawesi. Hum. Ecol. 39 (1), 55–68.

Roth, D., Boelens, R., Zwarteveen, M., 2015. Property, legal pluralism, and water rights: the critical analysis of water governance and the politics of recognizing "local" rights. The Journal of Legal Pluralism and Unofficial Law 47 (3), 456–475. https://doi.org/10.1080/07329113.2015.1111502.

Sanchis Ibor, C., Boelens, R., García Molla, M., 2017. Collective irrigation reloaded. Recollection and re-moralization of water management after privatization in Spain. Geoforum 87, 38–47. https://doi.org/10.1016/j.geoforum.2017.10.002.

Sanchis-Ibor, C., García-Mollà, M., Torregrosa, T., Ortega-Reig, M., Sevilla, M., 2019. Water transfers between agricultural and urban users in the region of Valencia (Spain). A case of weak governance? Water Security 7, 100030. https://doi.org/10.1016/j.wasec.2019.100030.

Sanchis-Ibor, C., Ortega-Reig, M., Guillem-García, A., Carricondo, J.M., Manzano-Juárez, J., García-Mollá, M., Royuela, Á., 2021. Irrigation post-modernization. Farmers envisioning irrigation policy in the region of Valencia (Spain). Agriculture 11 (4), 317. https://doi.org/10.3390/agriculture11040317.

Shah, Esha, Boelens, Rutgerd, 2021. The moralization of hydraulics: Reflections on the normative-political dimensions of water control technology. Geoforum 121, 93–104. https://doi.org/10.1016/j.geoforum.2021.02.009.

Siri, J., 1998. Analyse-diagnostic du système agraire des communes de setbo et svay rolum dans le district de Saáng (Cambodge). Mémoire d'ingénieur Agronome, Institut National Agronomique Paris-Grignon, Paris.

SOFRECO, 2018. Project Review Report. Water & Agriculture Sector Programme (WASP) – Package 2. Technical Assistance for the Implementation of Preks of Kandal Component (TA-Preks). SOFRECO, Phnom Penh, Cambodia.

Strauss, A.L., 1987. Qualitative Analysis for Social Scientists. Cambridge University Press.

Van der Zaag, P., Juizo, D., Vilanculos, A., Bolding, A., Uiterweer, N.P., 2010. Does the Limpopo River basin have sufficient water for massive irrigation development in the plains of Mozambique? Physics and Chemistry of the Earth, Parts A/B/C 35 (13–14), 832–837.

Veldwisch, G.J., Venot, J.P., Woodhouse, P., Komakech, H.C., Brockington, D., 2019. Re-introducing politics in African farmer-led irrigation development: introduction to a special issue. Water Alternatives 12 (1), 1–12.

Venot, J.P., Clément, F., 2013. Justice in development? An analysis of water interventions in the rural south. Nat. Res. Forum 37 (2013), 19–30.

Venot, J.P., Jensen, C.B., 2022. A multiplicity of prek(s): enacting a socionatural mosaic in the Cambodian upper Mekong delta. Environment and Planning E: Nature and Space 5 (3), 1446–1465.

Verran, H., Christie, M., 2013. Doing difference together: towards a dialogue with aboriginal knowledge authorities through an Australian comparative empirical philosophical inquiry. Culture and Dialogue 1 (2), 21–36.

Villamayor-Tomas, S., García-López, G., Scholtens, J., 2020. Do commons management and movements reinforce each other? Comparative insights from Mexico and Sri Lanka. Ecol. Econ. 173 (C).

Vos, J., Vincent, L., 2011. Volumetric water control in a large-scale open canal irrigation system with many smallholders: the case of Chancay-Lambayeque in Peru. Agric. Water Manag. 98 (4), 705–714.

Vos, J., Boelens, R., Venot, J.P., Kuper, M., 2020. Rooted water collectives: towards an analytical framework. Ecol. Econ. 173, 106651.

Whaley, L., 2018. The critical institutional analysis and development (CIAD) framework. Int. J. Commons 12 (2), 137–161.

Woodhouse, P., Veldwisch, G.J., Venot, J.P., Brockington, D., Komakech, H., Manjichi, Â., 2017. African farmer-led irrigation development: re-framing agricultural policy and investment? J. Peasant Stud. 44 (1), 213–233.

Zwarteveen, M., Roth, D., Boelens, R., 2005. Water rights and legal pluralism: Beyond analysis and recognition. In: Roth, D., Boelens, R., Zwarteveen, M. (Eds.), Liquid Relations. Contested Water Rights and Legal Complexity. Rutgers University Press, New Brunswick, New Jersey and London, pp. 254–268.