Explaining societal change through bricolage: Transformations in regimes of water governance

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Abstract
This paper is motivated by the pressing need to understand how water use and irrigated agriculture can be transformed in the interests of both social and environmental sustainability. How can such change come about? In particular, given the generally mixed results of simplified, state-initiated projects of social engineering, what is the potential for transformations in societal regimes of governance to be anchored in the everyday practices of farmers? In this paper, we address these enduring questions in novel ways. We argue that the concept of bricolage, commonly applied to analysing community management of resources, can be developed and deployed to explain broad societal processes of change. To illustrate this, we draw on case studies of irrigated agriculture in

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Saharan areas of Algeria and in the occupied Golan Heights in Syria. Our case analysis offers insights into how processes of institutional, technological and ideational bricolage entwine, how the state becomes implicated in them and how multiple instances of bricolage accumulate over time to produce meaningful systemic change. In concluding, however, we reflect on the greater propensity of contemporary bricolage to rebalance power relations than to open the way to more ecological farming practices.

Introduction

The use of water for irrigated agriculture still holds much promise in terms of economic growth and development. The availability of surface and groundwater has allowed considerable expansion and intensification of agriculture, most notably in arid areas. However, governing water for agriculture is notoriously challenging – past and current models of management have often proved disappointing and ineffective (Molle, 2008). Tensions in the governance of irrigated agriculture have long been documented between individual and collective interests, short-term gains and long-term sustainability. These tensions are currently heightened as the drive to extend and intensify agriculture in the interests of the economy, food security and development is prompting widespread concerns about the depletion and degradation of water resources (Taylor, 2014) and the related marginalisation of vulnerable communities (Perreault, 2014). As the material conditions of society's reproduction are threatened in many locations (Rockström, 2015), there is a pressing need to find more sustainable ways of managing water – for facilitating transformations to social and ecological sustainability (Feola, 2015; Zwarteveen et al., 2021).

This need to transform water use and management in irrigated agriculture raises a number of questions. Can such change be generated 'from above' – through science and policy initiatives that emphasise engineering, regulation and data as central to optimising water management? Or is meaningful change more likely to come 'from below' through the actions, initiatives and resistances of farmers and water users themselves? Expressed more broadly, can we explain how systemic change comes about (Scoones et al., 2020)?

Our approach to addressing these questions is shaped by our work on the Transformations to Groundwater Sustainability (T2GS) research project. In T2GS, working with colleagues from around the world, we study promising grassroots initiatives of people managing ground and surface water in places where pressures on the resource are particularly acute. In this paper, we draw on three contrasting cases where substantial change has taken place in water governance and in agricultural systems over the past few decades. We use these cases – two from Algeria's Sahara and one from the occupied Golan Heights (oGH) in Syria – to explore how the everyday actions of water users have generated these transformations.

The starting point for our analysis is the concept of 'institutional bricolage' (Cleaver, 2002, 2012; Cleaver and Whaley, 2018; De Koning, 2011). Much of the institutional bricolage literature investigates how local communities adapt governance arrangements, often introduced by government and development agencies, to fit their circumstances and lifeworlds. The focus is on the creative blending of the rules and norms involved in the management of natural resources such as water, forests and grazing lands, the attribution of meaning and legitimacy to them and the ways

in which power works through such hybridised arrangements. The orientation of institutional brico-lage studies has generally been towards single case studies of community-level practices and arrangements (Liebrand, 2015), though there are a growing number of cross-case and multi-case analyses (Gebara, 2019; Haapala et al., 2016; Sehring, 2009; Wang et al., 2021).

We argue here that the concept of bricolage can explain societal or systemic change at scales beyond the water committee, community, or project. Building on, extending, and blending previous iterations of bricolage, our approach in this paper is novel in a number of ways. First, we show that bricolage is not practised merely over rules. Rather, institutional bricolage is constantly entwined with processes of *technological* and *ideational* bricolage. Being a three-dimensional set of prac-tices, with each dimension feeding back and transforming the others, gives the overall process of bricolage a strong expansionist dynamic, as illustrated in Figure 1. We highlight just how these dimensions of bricolage interact to produce arrangements that are *more than* pragmatic improvisa-tions of rules, roles and norms, but which carry particular meanings and (re)shape material artefacts, social relations and the environment. Our cases illustrate how bricolage processes in combination can produce systemic change (Algeria) and become implicated in broader movements of claiming political identity, land and citizenship (oGH).

Second, addressing the state as a key concern of political ecology (Harris, 2017; Loftus 2020) and a gap in critical water studies (Mollinga, 2019), we show how bricolage is often a state–society co-production. In line with the 'State-in society' perspective put forward by Migdal (2002) we consider the State neither as a monolithic entity nor a fixed one, but rather as a 'field of power' shaped by 'the actual practices of its multiple parts', (pp. 16–17). In the cases that we analyse the action or inaction of a variety of state agencies and representatives necessitates brico-lage; State bureaucracies tolerate or become enrolled in innovations, legitimising, formalising and materially supporting adapted arrangements. We suggest how this enrolment of State actors, along with private sector actors (such as agricultural supply companies) contributes to the reach of adapted arrangements well beyond the village or water user community. These widely diffused
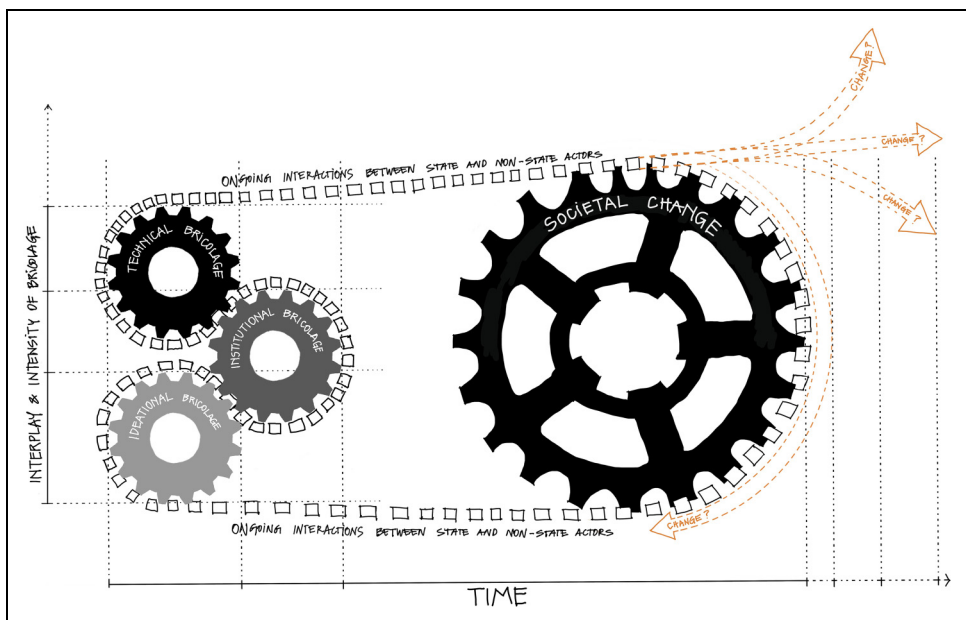

Figure 1. A theory of societal change through bricolage (drawing by Cristian Olmos Herrera).

arrangements have potentially significant effects on the patterning of governance and the distribution of resources in society.

Third, we highlight that bricolage is inherently a multi-scalar process. Rather than taking place at the local level before being potentially 'scaled up', it is continuously the product of multiple types of actors operating simultaneously in different, entwined, social domains. Our case studies show how bricolage involves a variety of local, regional, national, and sometimes international, actors. Thus, each particular instance of bricolage is already much wider in scope than a focus on local creativity and adaptation alone would suggest.

Fourth, we show that these defining features of bricolage (i.e. a three-dimensional process, a state–society co-production and a multi-scalar set of practices) allow for transformative change in agricultural systems and regimes of water governance. Whilst bricolage processes may often reproduce entrenched inequalities, our cases show that they also have the potential to mitigate structural power asymmetries and to pluralise governance arrangements. This potential to alleviate social domination, however, leads us to a further critical question: how far can processes of bricolage facilitate transformations to *ecological* sustainability? Institutional bricolage analyses often focus on the social implications of adapted arrangements, and the implications for poor or excluded people. Here we re-focus on environmental concerns and reviewing our empirical material, we question how far systemic changes wrought through bricolage are compatible with transformations to sustainability.

The paper proceeds as follows. In the 'Conceptual framework' section, we outline our conceptual framework, elaborate on the different elements of bricolage and relate these to issues of the state, society and scale. In the section 'The empirical cases of Algeria's Sahara and the oGH', we present our empirical material, focusing on tracing the interplay between institutional, technological and ideational processes of bricolage. In the 'Discussion' section, we work through the cases to explain how a transformative change in water governance and agrarian systems happens. We then broaden the discussion to reflect on whether entwined processes of bricolage can contribute to transformations to socio-ecological sustainability. The 'Conclusion' section concludes.

Conceptual framework

The theoretical underpinning of this paper is the concept of institutional bricolage, nested within a wider body of critical institutional scholarship and informed by political, cultural and social theory.[1] We complement this by drawing from two separate – but aligned – literature that mobilises compatible concepts of bricolage. Recognising that this literature has different intellectual origins, we nonetheless see promise in engaging with their deployment of the concept of bricolage. We thus weave into our analysis insights from science and technology studies showing how technologies are developed, adapted and widely diffused through bricolage (Ciborra, 1996; Garud and Karnoe, 2003; Naouri et al., 2020). Additionally, given our emphasis on state–society co-production, we draw from policy studies and political sociology literature concerned with how state actors also engage in bricolage and to what effect (Allain & Madariaga, 2019; Carstensen 2011; Hannah, 2020).

In this paper, we separate institutional, ideational and technological processes of bricolage for analytical purposes, although they are, in reality, inextricably linked. For instance, ideational bricolage conveys meaning and authority to adapted institutional arrangements; irrigation technology and society are mutually constituted (Van der Kooij et al., 2015); while technological bricolage can at times be interpreted as subversive practice, challenging existing power relations and shifting water governance (Kuper et al., 2017a). In what follows we thus present the three different

processes of bricolage, trace their interactions, and highlight the role of both state and non-state actors in enacting and facilitating bricolage.

Institutional bricolage

In developing the concept of institutional bricolage, Cleaver (2012) set out to show how institutions for the management of natural resources are formed, and how they function. Institutional bricolage is a process in which people consciously and non-consciously innovate by drawing on existing social material (styles of thinking, social norms, sanctioned roles and relationships, orders and arrangements) to piece together institutions which work in particular contexts. The resulting arrangements are often hybrids; a curious mix of the formal and informal, commonly serving multiple purposes and operating patchily, according to need.

Bricolage arises from the necessary improvisation of social practice; people must constantly adapt to changes in the social and natural world around them (Bourdieu, 1977). Such practical improvisations are often incremental – the tweaking and blending of existing arrangements to better suit changed circumstances. But they may also involve innovations – the introduction of new elements borrowed from other contexts, or the radical recasting of roles, rules and mechanisms. Much of the institutional bricolage literature pays significant attention to the ways in which the agency of bricoleurs is creatively exercised in these ways (Liebrand, 2015). Similarly, in the political science literature, analyses of policy change through bricolage have highlighted the role of 'interpretive entrepreneurs' who select and communicate certain ideas from the many existing options, translating and accommodating them to the logic of specific policy fields (Campbell, 2010: 105).

However, innovation through bricolage is also constrained. First, in their creative improvisations, bricoleurs can only draw on the institutional principles and practices at their disposal, within particular contexts (Sehring, 2009). The social structure thus shapes (as much as it is shaped by) the creative agency of bricoleurs and numerous studies show the 'capture' of local institutional arrangements by elites (Rusca et al., 2015). Second, in order to work, bricolage arrangements must appear legitimate, they must seem in some way natural, to socially fit (Douglas, 1987). This fit is achieved in different ways: by invoking tradition; by analogy to accepted ways of doing things and by calls on authoritative discourses and the symbols and artefacts that represent these (Boelens, 2015; Cleaver, 2000, 2012). As an example in the policy field, when key neo-liberal principles (e.g. use of markets to allocate resources or competition) were introduced in Germany and Sweden, they had to be presented as a renewal of traditional, social-democratic ideas, thus leading to hybrids of 'corporatist-managed liberalization' in which 'social partners' are important participants with management in ensuring firms' international competitiveness (Jackson and Schnyder, 2013).

In summary, bricolage is a creative and adaptive process but history, social structure, power relations and meanings are all critical to how it works, and to the effects it produces. Processes of institutional bricolage occur through everyday adaptations in social practice but are distinguished by a number of key features. These include (1) the hybrid nature of arrangements pieced together from different elements; (2) the importance of the meanings carried in the component parts of these arrangements; (3) the ways which in bricolage is an authoritative process, shaped by relations of power and the variable capacities of bricoleurs. The combination of these factors means that processes of institutional bricolage, whilst shaped by history and social structure, are not entirely predictable or amenable to conscious design, but are characterised by intermittence, diversity and unintended consequences.[2]

Ideational bricolage

From an institutional bricolage perspective, governance arrangements work partly because they are imbued with meanings and values. Bricolage is therefore never a purely instrumental endeavour,

but is always a symbolic and imaginative process as well (Campbell, 2004: 70). The attribution of meaning conveys authority and legitimacy and therefore helps to ensure the acceptability and durability of new or adapted institutional arrangements.

These meanings may be pieced together from various sources. Worldviews provide explanations of phenomena, models of desirable social orders and the rationale for remedying misfortunes and imbalances (Cleaver et al., 2021). As some of the idea-oriented political science has long argued, dominant policy approaches draw on particular logic to frame problems, deploy narratives which suggest solutions and promote visions of desirable futures which justify particular allocations and arrangements (Blyth, 2013; Carstensen and Schmidt, 2016). Social and political movements also advance visions of desirable futures, based on concepts of just allocations, rightful shares and meaningful citizenship (Sanghera and Satybaldieva, 2021; Snow et al., 1986). All these sources provide the material for fashioning arrangements through bricolage and the means for investing them with legitimacy and authority.

These various ideational sources are unlikely to be complete systems of thought, but hybridised assemblages of different logics, narratives and values. For example, worldviews combine aspirations of the modern with an assertion of the values of tradition (Cleaver et al., 2021); public policies blend different agendas through translation, trade-offs and accommodation, amounting to an ongoing process of 'creative syncretism' (Berk and Galvan, 2013) while providing sufficient polysemies to cater to different social groups (Ennabih and Mayaux, 2020; Parsons, 2016). Political movements often combine the pragmatic and the ideological, borrowing tactics from aligned initiatives and building heterogenous alliances (Walter and Urkidi, 2015), smoothing over value differences. Further complexity is provided by the location of resource governance in the multiplex relations of everyday lives, where the principles shaping the distributions of water, land, food, and social identity overlap (Schnegg, 2018). Of necessity, bricoleurs (farmers, irrigation officials, and policymakers) thus become adept at navigating social interfaces and differences in values, interests, resources, knowledge and power (Funder, 2020; Landini et al., 2014).

A focus on ideational bricolage brings into scrutiny the ways in which power is exercised through ideas. Like any exercise of power, ideational bricolage may be undertaken deliberately, strategically drawing on particular narratives to justify or oppose allocations of resources. But it may also work less consciously, quietly shaping people's perceptions of their needs through incremental changes, taken-for-granted rationales, orders and roles. Power works invisibly through such processes to shape subjects and make certain arrangements seem like the right way of doing things (Svarstad et al., 2018; Whaley, 2018). Political scientists also distinguish between political ideas that are deliberately manipulated in the foreground of political debates (strategic bricolage) from those underlying assumptions and core beliefs that invisibly shape less conscious processes of bricolage, in the background (Campbell and Pedersen, 2014; Hannah, 2020).

We often think of meanings as purely ideational or discursive – the rationalities, representations and types of knowledge that shape resource governance dynamics. But meanings are inextricably linked with material things (Folch, 2019; Scott, 2008). In social structures, material allocations (of money, labour, commodities, and infrastructure) are shaped by the authority of particular discourses and rationalities. And in the necessary improvisations of everyday life in biophysical environments, people's ideas about desired orders, and imagined futures manifest in their embodied interactions with the physical environment, infrastructure and technology. This point now leads us to a consideration of the dynamics of technological bricolage.

Technological bricolage

A key focus in critical perspectives on environmental governance concerns the ways in which biophysical and social processes interact to shape resource allocations in society (Whaley and Cleaver,

2017). Here we define the biophysical as relating to technologies (machinery, equipment, and associated knowledge), infrastructure, and the broader physical landscape, as well as the physiological (embodied) attributes of actors in the social situation (Whaley, 2018).

Our focus is on the ways in which water users dynamically interact with technologies, through their everyday practices. In this paper, we focus on technologies for accessing, distributing and storing water and the ways in which water users appropriate them, adapting them to fit local circumstances and changing purposes. Social dynamics are inextricably bound into technological bricolage. For example, the embodied knowledge and skills of the bricoleurs enable or constrain their technological tinkering. Thus, small-scale farmers in Morocco learned about drip irrigation by working as labourers on large-scale farms and then invented a low-cost drip irrigation system to make it work on their own farms (Benouniche et al., 2014). Their socio-economic relationships, and the time and labour required to adapt, produce and use technologies, all offer various constraints and opportunities for innovation. Laws, rules and norms are implicated in the operation of technologies, and the meanings associated with them affect the extent to which they are adopted and by whom. Practices of technological bricolage are therefore social as well as material and have the potential to reinforce or reshape societal arrangements.

In regard to the technologies and infrastructure of irrigation, critical water scholars have deployed terms such as 'bricolage', 'socio-technical tinkering' and 'braconage' (or poaching) to capture what happens when designed systems or interventions are translated into everyday realities 'on the ground' (e.g. Kemerink Seyoum et al., 2019; Kuper et al., 2017a). Common to these approaches is a focus on the emergent nature of governance arrangements formed through social practice. Such socio-technical arrangements are not fixed, finished or finite but constantly in the process of coming into existence or prominence, and constantly being re-made. From such perspectives, practices of technological bricolage have relevance beyond the immediate situation in which they occur: they are implicated in reinforcing or shifting water governance and societal orders more broadly (Benouniche et al., 2014; Venot et al., 2014).

A note about societal change and scale

In order to understand how societal change happens we need to extend our focus beyond discrete events and localised arrangements. This replaces the question of how we conceptualise the scalar dimensions of governance.[3] In this paper, we understand governance interactions to take place in intersecting social domains, not wholly captured by the notion of hierarchical local, national, and global levels of territory or organisation. We are aligned with ideas about scale as being both materially *and* socially constructed, potentially *both* fixed and fluid, and inherently relational (Brown and Purcell, 2005; Norman et al., 2012). From our analytical perspective, the adjustments that people make to arrangements in particular contexts, hold the potential to gain reach across space and time (to become diffused or upscaled). This happens through entwined processes of institutional, technological and ideational bricolage. The social and material resources that are drawn upon in these bricolage arrangements are also the medium through which societal structures are reproduced or transformed. These 'emergent' social structures are typically unintended. The farmer, tinkering with irrigation technology does not *intend* to transform society, and yet when that tinkering is repeated by many farmers and regularised in new or hybrid configurations of governance, it may well contribute to that transformation (e.g. Naouri et al., 2020). In this paper, we use the term 'upscaling' to refer to such processes.

The empirical cases of Algeria's Sahara and the oGH

For this paper, we compiled three contrasting case studies from material previously collected in our respective research sites. This cooperative analytical exercise was in the spirit of the T2GS

project in which we endeavour to learn across unlike cases, within an overarching concept framing which includes bricolage, along with the transformative potential of everyday 'caring' and 'sharing' practices. We thus designed a specific academic exercise with the aim of using a bricolage lens to re-analyse pre-existing data. We selected these three case studies because we already had an in-depth understanding of (1) the historical water dynamics in these contexts and (2) how local practices were connected to wider changes in water governance and agricultural systems. We had studied and documented these cases in recent years using ethnographic methods (elaborated in Dajani and Mason, 2018; Naouri et al., 2020). In the cases of Biskra and Ghardaïa, we drew on our research on farmer-led open innovation processes related to drip irrigation systems drawing on the recent literature on technology translation (Naouri et al., 2020). In the oGH, we focused on research which looked at small water infrastructure developed by communities challenging the infrastructural choices made by the occupying power to harness water for settlement agriculture (Dajani and Mason, 2018). To produce the analysis presented in this paper we first investigated, using the empirical data, the three different (but entwined) processes of bricolage and their interactions, while highlighting the role of different state and non-state actors. We then linked practices of bricolage to the larger societal dynamics at play by studying carefully how the different arrangements reach across space and time. Our aim in working through unlike cases was not primarily to demonstrate the uniqueness of each case (though they certainly *are* each unique), nor to claim that they are somehow representative of all instances of bricolage governance arrangements. By bringing these unlike cases into engagement, with data that allows us to track the evolution of processes over several decades, we argue that we are able to make *generalisations to theory*. By that, we mean that we asked the same theoretical questions to all three cases, allowing us to guide and structure data analysis, thereby making systematic comparison and cumulation of the findings of the case possible (George and Bennett, 2005). In other words, we use our three context-specific cases to experiment with an analysis that moves beyond tracking local practices to explain how societal change may come about through bricolage.

Algeria's Sahara: The tale of two contrasting agricultural frontiers[4]

The importance of bricolage in the development of Saharan agriculture. Algeria's Sahara has been a site of tremendous development of irrigated agriculture over the past 30 years, based on abundant groundwater resources and favourable climatic conditions which enable off-season horticulture. This contributes to national food security and to supplying the cities in the North of the country with vegetables, fruits, cereals and livestock feed. Such agricultural development is often seen as the result of ambitious government programmes, providing access to land and capital. However, we argue that bricolage by farmers and artisans, interacting both with state actors – the Agricultural Services, the Office of Agricultural Land, the Water Resources Directorate, and the District Prefecture of the Ministry of the Interior (Wilaya)- and with (inter)national companies has played a crucial role in this development (Kuper et al., 2017a). Our argument is based on the analysis of two distinct agricultural areas in the Sahara. Both areas have undergone major change, as a result of technical and institutional bricolage. In Biskra, 25,000 smallholders and artisans gained control over the design and deployment of innovative drip irrigation to develop greenhouse horticulture, producing one-third of the nation's tomatoes, along with bell pepper, aubergines, melons and watermelons (Naouri et al., 2020). In Ghardaïa, farmers have enrolled the state in developing collective arrangements for accessing groundwater through a combination of technical and institutional bricolage. In both cases, the bricolage institutions and technologies, produced by the actions of smallholders, became 'upscaled' and shaped systemic transformations in resource access, water use and agricultural intensification.

Smallholder-led drip irrigation in Biskra. Around Biskra, sometimes called the 'Eldorado of Sands', the availability of land and water resources attracted thousands of young farmers with experience in greenhouse farming on Algeria's northern coast, to develop a new agricultural frontier (Amichi et al., 2020). Vegetables have always been cultivated in the oasis, but in very small quantities, on tiny plots, for self-consumption. What is new is the orientation towards the market-oriented intensive production of early vegetables under greenhouses. Before the smallholder revolution, the landowner – very present on his farm – would move the greenhouses across the farm, integrating them into a rotation including other crops such as barley. The main objective of local landowners was to plant palm trees, -the lucrative *deglet nour* variety- and greenhouse farming remained marginal. In this system, the landowner owned the land, greenhouses and water access. For expertise and labour, young farmers were recruited as labourers or sharecroppers with little scope for advancement. Limiting factors included their lack of access to land, water and capital and the restricted number of greenhouses on each farm.

To overcome these constraints, landowners and young farmers engaged, first, in institutional bricolage by devising organisational arrangements that enabled them to expand access to land, water and commercial inputs through resource pooling[5] (Amichi et al., 2015). Most landowners did not have enough financial capital and practical knowledge to invest in the emerging greenhouse farming system. Moreover, these landowners were more interested in the less labour-intensive and lucrative palm trees. However, creating a palm grove is a very costly enterprise and palm trees only start to produce after five years. The simple but far-reaching idea was to combine two distinct but complementary farming systems on the same plot: the gradual planting of perennial palm trees by landowners, financed by the ephemeral greenhouses cultivated by young sharecroppers, who would move on to 'virgin' plots once the existing plot was fully planted with palm trees. This prompted negotiations between landowners and landless young farmers to ensure each could secure access to production factors. Thus, the landowners invested only in clearing the land and installing tube wells which enabled them to rent out the land to young farmers who mobilised their greenhouses and know-how. Based on their experiences, these young farmers agreed to pay rent to landowners for each greenhouse installed with access to water for at least three hours, twice a week. The greenhouse farming system proved lucrative, enabling young sharecroppers to build financial capital, and started to attract more attention. A number of sharecroppers were able to leave the hard work in the greenhouses by becoming lessees, renting the land and access to water from landowners, and engaging (younger) sharecroppers to do the physical work. In this way, an agricultural ladder was gradually established and regularised, allowing for some upward socio-professional mobility. Young farmers were able to move, within a few years, from the status of a labourer to sharecropper or even lessee employing several sharecroppers (Naouri et al., 2015).

Second, as an effect of institutional bricolage, these emerging smallholder farmers engaged in technological bricolage by developing low-cost and functional drip irrigation infrastructure (see Naouri et al., 2017, 2020), thereby challenging the drip kits provided by (inter)national companies, despite the fact that they were subsidised by the Ministry of Agriculture through different programmes managed by the District Agricultural Services and the General Office for Agricultural Concessions. The new farm structure needed more decentralised irrigation management to accommodate the variation in irrigation and fertigation[6] schedules between greenhouses. In this new organisation, each smallholder (lessee) was making his own choices about which crops to cultivate and agricultural practices to adopt. The smallholders started incrementally adapting the drip irrigation system by eliminating some parts and redesigning others, to create more flexibility and agility in the system. The distribution companies, which had provided the standardised drip irrigation systems, eventually responded to these local innovations and supplied the equipment required by the smallholders. Smallholders were proud of the drip irrigation system they had designed and

forced the multinational manufacturers and distribution companies to adapt the supply of equipment to their requirements. In this way, processes of bricolage, initiated by smallholders, reshaped the system of greenhouse horticulture. Today, Biskra has more than 150,000 greenhouses operated by more than 25,000 young farmers. Throughout this process, the interactions with the state were indirect but decisive. First, the technical state services related to agriculture and water resources demonstrated the presence of water resources and the potential to engage with market crops (Amichi et al., 2020), despite the fact that a lot of the state-sponsored agricultural initiatives were considered failures (Otmane and Kouzmine, 2013). Second, various State services enabled the agricultural frontier we described by developing the necessary local infrastructure: agricultural services for rural roads, farms electrification and subsidies for agricultural equipment; municipalities and districts for larger roads and markets; the relevant ministries for health and education. Third, agricultural services, the Agricultural Land Office and the Water Resources Directorate all tolerated the use of land, water and agrochemical products with minimum control. In return, these dynamic farming systems turned out to be very helpful in feeding the main cities in the north. This co-production of bricolage by state and non-state actors is even more evident in another Saharan location, Ghardaïa.

Ghardaïa: State–society co-production of bricolaged access to groundwater. In the El-Ateuf irrigation scheme in Ghardaia, farmers have been able to individually and collectively access and manage groundwater, in quantities and quality necessary to develop their agricultural activities. This has happened over the past 45 years through several stages of mutually reinforcing technical and institutional bricolage, enacted between water users and state actors. It started in 1974 when a group of local farmers were attracted to the area, thought to be situated in an ancient river bed, which the farmers associated with relatively easy access to water. In the first step, farmers manually (and informally) dug individual shallow wells of around 35 m depth in the phreatic aquifer.[7] In less than 10 years, the District technical services had regularized the shallow wells. However, the quality of water from the phreatic aquifer was not good enough for a number of crops and animals.

   In the second step, the farmers requested state support for access to the deeper Albian aquifer.[8] At the beginning of the 1990s, the District technical services installed a deep tube well and implemented an irrigation scheme project based on the collective use of the resource. The project was initially designed to serve 25 farmers with a distribution system at the farm level. Most farmers kept their shallow wells as a safety measure. The Water Ressources Directorate managed the system and farmers were supposed to share total energy costs on an equal basis, regardless of volumes consumed by each user. However, the maintenance of the tube well and other equipements were neglected. State management turned out to be not operational and ended up with a broken pumping system and unpaid energy bills.

   In the third step, in the face of management problems with no clear water consumption rules, the idea of creating a water users' organisation was suggested but a legal framework was missing. A 'farmers group' was created by the users, which now has a formal existence but is not supposed to manage water. The users agreed amongst themselves to pay for volumetric consumption measured through water meters. They elected a president and put an accounting system in place. To prove their engagement, members contributed to a common fund to finance repairs needed to restart, and henceforward maintain, the pumping and distribution systems. In parallel, the farmers' group negotiated with the District services with the support of the Agricultural Services to take on co-responsibility in managing the irrigation scheme, implicitly inviting the state to engage with institutional bricolage. Operating under the state's umbrella was seen by farmers as crucial for securing further investments. Inside the group, rules were established to make the rights and duties transparent and open for negotiations. The informal rules were perceived as adaptive and thus more legitimate.

The new mode of management attracted more farmers who wanted to access the Albian aquifer. To respond to the increasing demand, some technological bricolage was needed. In the fourth step, secondary connections were thus added to the network to serve new farmers. At some point, the distribution system was serving more users than it was designed for. Farmers far away from the source were having pressure issues which pushed them to use small pumps to boost the pressure. A victim of its success, the number of users of the system increased to more than 180 farmers. The pressure on the system was too high and communication among members became complicated. In the fifth step, the board of the farmers' group agreed with the members to split the scheme into two parts. The adaptive and negotiating capacity of the farmers led to the creation of a new irrigation scheme around an existing state-financed (relief) tube well. Users in this new irrigation scheme developed their own rules adapted to the new conditions, by increasing the fixed charges and reducing the variable charges (price per cubic meter) compared to the first group.

The dynamics of multi-scalar bricolage. In addition to the farmers/water users, processes of bricolage involve other actors active in different social domains and levels of an organisation. In Biskra, the negotiations, dialogues, and technical and institutional adjustments involved smallholders, international manufacturers of irrigation equipment, multinational companies and the state, which financed the first development of drip irrigation. Similarly, communities in Ghardaia were able to enrol the agricultural administration in institutional bricolage around the collective management of groundwater resources, and the administration also tolerated the development of individual wells to secure agricultural production. In both cases, the state was, at the very least, 'tolerant' of technical–institutional bricolage but also generally 'supportive' through heavy investments in infrastructure.

As knowledge of these bricolage arrangements circulated, they inspired other groups of farmers. For example, in Biskra, the technological bricolage of the fertigation[9] systems of smallholders enabled their adaptation and transfer to the Canarian[10] greenhouses of large-scale farmers. Technological bricolage also provided meaning to a functional, low-cost, and in-house-developed drip irrigation system. Institutional bricolage led to a similar adaptation and transfer of the rules of income sharing between the different actors active in greenhouses, to these large-scale farms. The institutional bricolage around the organisation of collective tube wells in Ghardaïa is also transferable to irrigation schemes, which are facing problems in the access of groundwater, and where negotiations over collective access are ongoing. In these irrigation schemes, there is a high demand for successful experiences in technical–institutional bricolage for the sharing of rights/duties and the governance of tube wells. Bricolage is giving water users the flexibility to implement rules and technologies adapted to their own situations. In other words, it allows for the development and translation of technologies and rules in a context of incremental adaptation, generating more organisational sustainability. In the Algerian Sahara, the co-production of bricolage arrangements took place in a series of negotiations and power struggles with (inter)national drip irrigation manufacturers and the state (see Naouri et al., 2020, for more details on these negotiations and power struggles) while upholding a relatively stable political order (the Algerian 'black decade'[11] of the 1990s affected Saharan regions less than other areas). In this respect, the oGH provides a contrasting case, which illustrates how entwined processes of bricolage may also unfold in situations of military occupation and contested citizenship, where farmers' access to water is embedded in a broader political conflict.

The oGH,[12] Syria: From counter-infrastructure to embedded resistance

New meanings of water governance gradually forged through bricolage. In the past five decades, the oGH has witnessed a tremendous shift in political, cultural and economic realities under military

occupation by Israel. A formerly thriving population of Syrians, engaged in agriculture, were dislocated from their homeland and forced to construct new arrangements with an occupying power which controlled their means of production, marketing and every day livelihood practices. The remaining Jawlanis[13] engaged in acts to reclaim rights to their presence on the land and to reaffirm their worldview and way of life. Since the occupation of 1967, the Jawlanis have engaged in multi-sited processes of technological and institutional bricolage, changing the land and water governance within their communities and linking issues of identity and belonging with those of natural resource management. In tracing these multi-faceted processes, we explore how bricolage arrangements transformed Jawlanis' relationship with the state from one of outright opposition (the building of counter-infrastructure) to one of resistance-through-incorporation (via formalised water cooperatives and related infrastructure). We show how ideational bricolage plays a crucial role in ensuring that adapted institutional and technological arrangements are seen as justified and necessary ways of continuing to resist the occupying state.

From resistance infrastructure to negotiated co-option. In May 2019, representatives of agricultural cooperatives in the oGH[14] issued a statement to the local Jawlani community. This related to an incident whereby the Israeli government water company (Mekorot)[15] had uprooted 7-year-old cherry trees from land belonging to a Jawlani farmer in al-Musheirfeh area. The statement was intended to counter misunderstandings that this action was a state encroachment on farmers' land, explaining that it was actually prompted by the cooperatives themselves, in negotiation with Mekorot. The joint aim was to increase the water quota attributed to local farmers by rehabilitating the company's well. That well is located next to the farmer's land, and the company rented a plot from him in order to expand its works and place its machinery. This al-Musheirfeh well symbolises the complex and partly synergetic relationship that has developed between the Jawlani farmers and the Israeli state officials over five decades of military occupation. Woven through this relationship are entwined processes of technological, institutional and ideational bricolage.

   To grasp the symbolism of the al-Musheirfeh well, some historical reflection is required. In the 1970s, the water company confiscated Jawlani lands in the area as part of its exploration of water sources for the benefit of Israeli-Jewish settlements. Five wells were dug in the heart of the Jawlani land and their waters were pumped exclusively to Jewish settlements in the region. The Jawlani farmers, who relied solely on al-Musheirfeh spring and two further local springs to irrigate their lands, protested against the development of these wells, correctly claiming that their own water sources would dry up. Simultaneously, the community was denied access to another water source, a volcanic lake called *Briket Ram*, which Mekorot also claimed as state property and made available to Israeli settlements only. Surface and groundwater abstraction, and related infrastructure, thus became an exclusively Israeli (state) activity, one that the local community was excluded from. In reaction, the Jawlani population began devising tools to reconfigure their agricultural practices and to centre them around reclaiming rights to water and land. To protect their land from state confiscation and to secure a modicum of economic stability, they decided that their agricultural activity had to be multiplied and expanded.[16] This required an extensive reconfiguration of landscapes (turning hilly terrain into terraced plots for apple cultivation) and waterscapes (devising methods to capture surface water and increase its availability for the newly rehabilitated lands). To these ends, a number of bricolage arrangements, technologies and practices were initiated.

Synergies between institutional, technological and ideational bricolage. In the 1970s and 1980s, the Jawlani farmers began to improvise with trial-and-error processes of capturing water. Technological bricolage was deployed to increase collective water availability. This was facilitated by the

Jawlani's expertise in local water management and their ability to access heavy machinery, due to their incorporation into the Israeli economy, primarily as construction workers. The Jawlani farmers started their 'trials' by pumping water from the lake at night and using mobile tankers to transport it to their land to irrigate their newly planted crops. When those trials failed to secure sufficient water, the farmers dug small ponds to capture rainwater. These proved to be extremely costly, labour-intensive and ultimately insufficient unable to meet the demand for water. The culmination of their efforts in technological bricolage, then, was the crafting of a circular metal tank, with a volume between 300 and 1000 m^3. The tank was seen by farmers as a triumph against the Israeli state and, with the first prototype successfully holding onto water, there was a 'mushroom effect'. These metal tanks started dotting the landscape, and hundreds of farmers began constructing them, empowered by a sense of collective action and solidarity. This was done in defiance of the Israeli Water Law of 1959, which prohibited the harvesting of rainwater for private use and treated all water as state property. All of these improvised attempts to deploy water technologies were punished by the state, which issued a series of fines, demolition orders and other punitive measures to curb their spread. Significantly, the technological bricolage took place at a time when Jawlanis were engaged in protests against the imposition of Israeli citizenship, and in issuing a collective statement identifying land and water rights as central to their struggle.

Faced with increasingly hostile state pressure, unfavourable conditions for marketing agricultural produce and fierce competition from the Israeli settlements, the farmers decided to demand water allocations directly from the Israeli water company Mekorot. Negotiations with Mekorot began in the 1990s, enabled by the establishment of formal water cooperatives (drawing on earlier collective arrangements for the management of water). The cooperatives created channels of negotiation and lobbying for water rights and quotas. The farmers were required to develop their own water supply network in order to purchase water from Mekorot. Here, an upscaling of arrangements occurred, which strengthened and further interconnected technological and institutional bricolage. This involved large investments from farmers in designing and developing a network of pipes and pumps to reach their plots, in addition to establishing financial mechanisms and organisational structures to ensure its realisation and maintenance. Whilst these 'incorporation' arrangements were a marked change of strategy, they were still underpinned by, and actually reinforced, the underlying logic of the counter-infrastructure initiatives – asserting identity, belonging, and claiming rights. More broadly, they illustrate how adapted arrangements are layered onto previous ones, with meaning leaking from one to another. Ideational bricolage is articulated when institutional arrangements are adapted to engage with the state in order to maintain the meanings and values associated with challenging unjust relationships of power with the occupying authorities.

Tense yet partly synergetic relations between state and non-state actors

In the statement issued in May 2019, the cooperatives express their gratitude for the farmer (Mr A.) whose land has been utilised by Mekorot:

> As cooperatives, we thank Mr A. for his cooperation with us by granting Mekorot access to his land so that we can provide additional water which will strengthen our attachment to the land and turn it into a green haven throughout the year.[17]

What this quote illustrates is the uneasy, complex and evolving realities of the relationship between the farmers and the Israeli state, and how processes of bricolage subtly change and alter this, creating new forms of patterning and meaning in existing structures. Before the 1990s, farmers were engaged in direct confrontation with the Israeli state, and even after the establishment of the cooperatives, the wells remained a site of farmer–state confrontation. In 2004, an emergency meeting was called by the Jawlani community upon being notified of the Water Authority's plan to

pump water from al-Musheirfeh spring. At the meeting, it was declared that 'we will protect our water with our bodies'.[18]

Simultaneously, however, the state/farmer relationship was also transactional and managerial, with the aim of increasing water quota for farmers. This required a level of 'negotiated incorporation' and compromise, as farmers were placed with the responsibility for developing their own network, which they have collectively fundraised for and pieced together themselves. Eighteen water cooperatives were established, and an assemblage of pipes, pumps and filters were constructed to channel the water sold to them by Mekorot. Through their collective lobbying efforts, the cooperative succeeded over a number of decades in securing substantially increased quotas of water from the company. However, underlying these transactions is the ongoing contestation with the state and continued opposition to the Israeli presence on their land.

In these dynamics, the mundane and banal standardisation mechanisms of the state are not void of meaning and value. Registering the water associations with the Israeli state required complying with the regulations and norms of the occupying power, as well as deep knowledge and embeddedness in a socio-cultural system which relies on a foreign language, Hebrew. From the contracts signed with cooperatives to water distribution and crop maps and even the computer software they must use, the farmers had to adapt to Israeli methods, logic and lexicon. Thus, the farmers use Hebrew terms consistently to describe crops, infrastructures, equipment and procedures. The cooperatives became a channel through which the occupying state made the oGH farming practices legible, controlled and monitored, with the farmers' acquiescence. The transformation of all agricultural land in the village to monocrop orchards exemplifies how the farmers not only had to speak the language of the state, but also to adopt its logic. Alongside this process, however, the planting of apple trees, renowned for their long life, has taken on a different meaning and become the material expression of a land-based political belonging, in opposition to the state (Mason and Dajani, 2019). Jawlani Apples have become a symbol of the identity of the oGH and its people and provide the roots for their physical existence on the land. Today, apple cultivation is a part-time job for many farmers, and indeed a costly and unprofitable one. Many of the Jawlanis comment that they became 'amateur farmers', growing apple trees, as a rite of passage to remain on the land. Under the unequal conditions of production and marketing, apple growing has become an economic burden on many growers, and most depend on other jobs (as lawyers, dentists, medical doctors, and construction contractors and workers) to earn a livelihood.

Discussion

Mutually reinforcing processes of bricolage

In general, studies have recognised that bricolage is a process unfolding over multiple, intimately connected dimensions. The literature on institutional bricolage, in particular, sees ideational bricolage as proceeding alongside, and directly supporting, the bricolage of rules (Carstensen, 2011; Cleaver, 2012). Similarly, other studies have shown how technological bricolage can generate institutional bricolage (Naouri et al., 2020; Whaley and Cleaver, 2017).

Our case studies build on these insights to show that it is possible for entwined processes of bricolage to recursively shape each other over long periods of time. Thus, bricolage is a process that can be sustained and reinforced endogenously, as each round changes the relative position of the actors and the circumstances they face, and thus provides them with renewed incentives and opportunities to adapt to these changed circumstances through additional rounds of bricolage. The point, here, is not that each sequence of bricolage mechanistically triggers subsequent ones, but that it paves the way for its own creative expansion as resourceful actors build on it in unforeseen

ways. The cumulative effects of these interconnected processes of bricolage can be much more transformational than is suggested by more segmented and short-term analyses.

Thus, in Biskra, processes of technical and institutional bricolage have prompted and reinforced each other over time. Because young farmers from the north had set up organisational arrangements that enabled them to access land, water and commercial inputs, they developed considerable interest in the development of low-cost drip irrigation infrastructure better tailored to their skills and resources. In turn, the success of low-cost drip irrigation meant that smallholders could extend the number of greenhouses cropped, which generated more resources to be pooled, further expanding these organisational arrangements and attracting yet more farmers from the north. Then, over time, institutional and technological bricolage had the joint effect of nurturing ideational bricolage, with the formation of a young Saharan farmer identity, pieced together from ideas of resourceful northern entrepreneurship blended with a broader frontier imaginary inspired by the American West (Amichi et al., 2020). In turn, this emerging identity favoured the establishment of institutional arrangements allowing for rapid upward social mobility.

In the oGH, Jawlani farmers first engaged in technical experimentation to resist Israeli occupation, covertly pumping and transporting water from the lake, digging small ponds, and fashioning metal tanks to capture rainwater. Over time, this technological bricolage put them in a better bargaining position to engage in institutional bricolage. Having developed their own water networks, they could negotiate to purchase water directly from Mekorot. Crucially, both technological and institutional arrangements were developed from historical and traditional practices employed by the Jawlanis in their long experience of seeking autonomy in natural resource management. However, the re-configured processes were developed in response to a drastic reconfiguration when the Israeli occupation transformed their geographical connection to their homeland. Under such an abrupt change, both institutional and technical adaptations reinforced, and were reinforced by, a bricolage identity of 'embedded resistance'. In this identity, pride and belonging are derived from frontal opposition to Israeli authorities, *and* from the ability to extract meaningful concessions from them. This defiant land-based identification, in turn, gives more impetus to their technological and institutional bricolage.

To capture these various linkages across multiple domains of social practices, a long-term analysis spanning several decades is required. Social change through bricolage, when considered over decades and across multiple terrains, then appears more unintended and unexpected than when the analysis is restricted to shorter historical sequences. It is the accumulation of multiple, disparate actions of bricolage that creates the systemic change – the bricoleurs did not set out with the purpose of upscaling their adaptations to a societal level. And it is by analysing the interdependent processes of institutional, ideological and technical bricolage over time that we can see how both planned changes and unanticipated consequences unfold.

The co-production of bricolage by state and non-state actors

In her work on institutional bricolage, Jessica De Koning considers three different ways in which communities respond to governance arrangements introduced by the state and other agencies (De Koning 2011, 2014). These relate to the degree to which imposed or introduced arrangements are absorbed into the social milieu of the community (aggregation); adapted and tweaked to fit better (alteration) or resisted through an assertion of alternative values, claims and distributions (articulation). Our cases illustrate that a combination of these processes occurs, producing varying outcomes in different sets of circumstances.

Our approach also emphasises the capacities of state actors to pragmatically adjust their own actions to initiatives from non-state actors (Funder, 2020). State actors do not merely coerce, ignore, or passively stand by as social processes of bricolage unfold. Rather, they often 'seek to

reproduce order through creative adjustments to rules and routines that channel action into predictable and controllable behaviour' (Jabko and Sheingate, 2018: 312). They seek to do this in two major ways, with varying degrees of success. First, they may choose to practice 'forbearance', knowingly tolerating informal creativity as long as its distributional consequences are deemed acceptable or even desirable (Holland, 2016; Tendler, 2002). Second, they may choose to formalise, materially support and legitimise adapted arrangements (Gallien, 2020). Thus, adapted arrangements are generally a site of 'hybrid governance' (Titeca and Flynn, 2014), one decisively shaped by state actors' endeavours to stabilise a social order.

Viewed in this light, frontal antagonism between state and non-state actors appears more as a temporary exception than as the rule. The case of the oGH illustrates well the gradual shift from radical confrontation to ambivalent negotiations between the Jawlanis and the Israeli State. Broadening De Konings's conception of articulation – to apply it to technological and ideational as well as institutional bricolage – the first historical sequence can be described as the construction of a 'counter-infrastructure' (Dajani and Mason 2018). This oppositional infrastructure articulated material artefacts such as pipes, pumps and storage; formal and informal regulations; and meanings of belonging and defiance. However, these counter-infrastructures gradually morphed into 'joint ventures' as the Jawlanis entered into negotiations with Mekorot. Today, this relationship remains extraordinarily ambivalent, as resistance to assimilation proceeds alongside everyday transactions and acculturation.

Likewise, in Ghardaïa, when the Algerian state introduced its own arrangements for the collective use of groundwater in the Sahara, its programmes were first countered, and in some cases simply discarded, by local farmers. Then a dialogue emerged that led to complex forms of groundwater co-management. In Biskra, existing arrangements prohibited young farmers, deprived of land, from accessing water. By re-engineering the drip irrigation systems and adapting the institutions to their fragmented farm structures, landowners and sharecroppers found a working formula for their intensive greenhouse farming systems. At first, Algerian authorities merely tolerated these informal arrangements, but as Biskra became the main supplier of off-season vegetable to the cities, they then helped these farmers by developing roads, electricity networks, and markets.

These observations show the productive potential for an articulation between research on state and research on societal bricolage. Indeed, bricolage might just be a particularly striking illustration of 'how states and societies transform and constitute one another' (Migdal, 2002).

Beyond local tinkering: Scale, society and change

Both case studies show that while bricolage is often initiated by local actors to experimentally adapt infrastructure or collectively organise livelihood practices, these processes may aggregate and leak across social domains to shape broader patterns of societal organisation.

Our analysis thus extends beyond understanding bricolage only as a locally situated process. It is true that bricoleurs take stock of existing ideas, institutions and technological know-how, and reinterpret them in the light of particular and changing circumstances. This might appear to suggest that bricolage is characterised above all by contextual diversity and that it cannot be generalised beyond the local (Carstensen, 2011). However, our cases show that the apparently limited character of bricolage is precisely what makes it such an effective vehicle for the diffusion of arrangements across space and time. By virtue of its familiarity, change through bricolage can appear more feasible (technological bricolage), legitimate (institutional bricolage) and meaningful (ideational bricolage) to all actors faced with comparable ecological conditions and sharing proximate cultural scripts. By appearing more natural and less intimidating than more ambitious changes, bricolage arrangements resonate and can be appropriated more easily. Such apparently

incremental adjustments, grounded in social context and meanings, can invisibly 'enable more radical changes than would otherwise be possible' (McAdam and Scott, 2005: 28)

Thus, in Biskra, the low-cost drip irrigation system spread rapidly across the region as it corresponded closely to the infrastructure already in place in the north, was less expensive to install than the high technology model, and appeared to fit better with a collective identity based on a sense of astuteness, flexibility and practical know-how. Similarly, in the oGH, the creation of counter-infrastructure through technological bricolage was possible because of the availability of local materials, machinery and manpower. Institutional bricolage was made possible by drawing on traditional arrangements of collectively managing and distributing water. What these entwined processes produced was a heightened sense of political subjectivity – strengthening farmers' motivations to enact them as a way of continuing to resist oppression. Through these negotiations, however, the *apparently* unchanged imaginary of defiance and resistance made possible the development of closer ties with the occupier.

The scope for socio-ecological transformations through bricolage

We have demonstrated that processes of bricolage can produce substantial changes to water access in a region or country and mitigate pre-existing forms of social domination. But how far can these changes be seen as *environmentally* sustainable? Can processes of bricolage facilitate the radical re-framing of the relationship between nature and society that is needed to further transformations to sustainability? In short, can we bricolage our way to some broader socio-ecological sustainability?

Much of the bricolage literature, concerned with how institutions channel power, process and meaning, has had relatively little to say on environmental outcomes (Cleaver and Whaley, 2018). And yet, we have seen in our case studies that bricolage engages material as well as social processes, and is enacted in biophysical environments.

Viewed in this light, the processes of bricolage that we track in our cases have not entailed, so far, any shift away from ecologically damaging modernist imaginaries and practices. Rather, they mostly show an appropriation of such imaginaries from below. This is especially true for two core features of modernism: first, a faith in technological control over nature, according to which even the most seemingly hostile, arid environment, can be productively harnessed through science, (irrigation) technology and infrastructure (Worster, 1992). Second, resource optimism anchored in the belief in the availability of an unlimited supply of land and water to increase production (Hamilton et al., 2015). This two-fold 'anthropocenic illusion' (Hörl, 2015) puts these bricolage arrangements at great risk in the medium term, as the material conditions of their reproduction may very well collapse.

Thus, in Biskra, intensive greenhouse horticulture cannot, in any way, be qualified as environmentally sustainable. Smallholders exploit little-renewable water resources, are exposed to toxic pesticides, degrade soil fertility and apply large quantities of fertilisers to the land. These smallholders do not see this entrepreneurial farming as a vocation, but rather as a way to obtain the means to lead a better life elsewhere (Naouri et al., 2017). Farmers are 'reasoning' their lives (and livelihoods) rather than reasoning their farming systems, especially in environmental terms. They do so by limiting the time they stay inside highly toxic farming systems (typically 5–10 years).[19] With the money made, they then get out and 'start' their lives for good (i.e. get married, build a house, diversify into less dangerous activities) elsewhere. Meanwhile, these toxic farming systems continue to provide fresh off-season vegetables to the cities, where consumers are supplied at a relatively low cost, which partly explains why they enjoy strong support from the state (Kuper et al., 2017b). The entwined processes of bricolage enacted by farmers and supported by the state and agricultural supply companies thus perpetuate unsustainable resource use.

In Ghardaïa, however, the way ongoing practices and imaginaries relate to modernism is more nuanced and quite different from Biskra. New agricultural extensions were first stimulated by the State to promote modern, intensive agriculture, as opposed to traditional subsistence agriculture in oases. Yet local communities invested in these extensions, bringing in their secular know-how of living and producing in the desert, which led to hybridised forms of agriculture that borrow from the oasis lexicon (e.g. the practices of layered agriculture; the association of livestock and crop production; or the circularity of water), while introducing new crops (such as saffron) and technologies (especially irrigation equipment). Taken together, these practices constitute an emerging 'Saharan farmer' identity, priding itself on being enterprising and independent vis-a-vis the Algerian State, but also on having a strong sense of belonging and caring for the environment. This distinguishes these farmers from those in Biskra, who come from the north of the country. The latter group's identity is also strong, as these young farmers are proud of their technical know-how in irrigation and greenhouse farming. They think they know better than the multinational corporations what sort of drip irrigation 'works' in Saharan conditions, and they designed for themselves the system they consider most appropriate. However, they do not identify as Saharan farmers, but as merely passing by (Kuper et al., 2017).

In the Israeli case, the promotion of sustainability in groundwater exploitation cannot be viewed uncritically as it occurs under conditions of inequality. While Israel promotes itself as a leader in wastewater treatment and reuse schemes in agriculture, it continues to exploit groundwater for the benefit of its illegal settlements in the occupied Palestinian territories and the oGH. Thus, groundwater sustainability must be analysed through its settler colonial lens and not just its techno-managerial advancement to expose social and political injustices embedded in those practices claiming sustainability.

In the oGH, the bricolaged technologies and institutions, and the meanings and values that they convey normalise unequal resource extraction. They do this by framing current arrangements as necessary for strengthening rootedness and attachment to the land. This is further complicated by the menace to the community's presence on the land of state-sanctioned projects of wind energy production threatening the Jawlani agriculture and way of life (Southlea and Brik, 2019).

The cooperatives, however, can still be seen as a site of resistance to forced cooperation. Since water allocations are only attributed during the dry seasons (mid-April to October), the pumping rates needed each month always exceed the allocation agreed upon. This is when the Natoor (guard for each cooperative) pumps beyond the agreed quota. This is seen as a way to secure the water that the farmers view as their rightful share. The logic behind this over-pumping relates to another claim that the farmers make to water rights, under the requirement in international law that an occupying power provides a basic level of services to the population it controls. It can be claimed that the development and diffusion of bricolage arrangements which took place following threats to the community's existence on the land have developed a sense of belonging that is centred around water, land and crops. However, the contribution of such processes to environmental sustainability remains highly questionable.

In sum, the different cases show that interdependent processes of ideological, institutional, and technological bricolage can bring about profound social and political transformations. One can also see, however, the limitations of the improvised character of bricolage. The pragmatic recombinations to which it gives rise may substantially alter power relations within a given development paradigm. However, the very nature of this paradigm, at least in our cases, continues to be largely derived from previous ways of thinking and doing things. Former contextual differences are thus merely renewed and maintained, without any fundamental bifurcation of the mode of development. In addition to its short-term orientation, which might prevent it from challenging particularly deep social structures, another limiting factor may lie in the fact that being a negotiated process, bricolage has to be at least tolerated, however reluctantly, by powerful actors.

This can pave the way for more equitable – at least temporarily – modes of development, but it also sets strong limits to any possibility of shifting towards a post-modernist development, less tied to capitalist growth. These reflections, nevertheless, can only be preliminary, and the potential effects of bricolage on ecological transformation should provide important avenues for future research.

Conclusions

We have identified in this paper three defining features of bricolage that have not received sufficient attention so far: first, institutional, technological and ideational processes are entwined and mutually reinforcing; second, bricolage is co-produced by the State and society; and third, it is always a multi-scalar process with multiple actors intervening continuously at different, connected levels. These features explain the transformative capacity of bricolage, its potential for mitigating social domination, and for opening avenues towards ecological sustainability.

Thus, mobilising a bricolage lens to analyse the potential for social–ecological transformations raises some productive questions. In particular, it avoids considering separately different ways forward to address fundamental socio-ecological problems, whether it is cultural change, innovative institutional arrangements or technological disruptions that are advocated. Instead, it invites us to explore to what extent processes of bricolage, operating over time on the three interdependent dimensions of institutions, worldviews and technology, can be self-reinforcing and foster genuine socio-ecological transformation. This also suggests that a meaningful systemic change to societal regimes of resource governance can be anchored in the everyday actions of farmers and water users rather than coming from simplified recipes implemented from above (Zwarteveen et al., 2021). The cases of the Algerian Sahara and the oGH, however, suggest that bricolage may more easily rebalance power relations within a productivist mode of development than transform irrigation practices towards greater sustainability. More research is therefore needed to examine if, and under what conditions, bricolage can open the way to something other than extractivism from below.

Highlights

- Entwined processes of institutional, ideational and technological bricolage can produce far-reaching transformations in regimes of water governance.
- Over several decades, bricolage processes have produced a systemic change to irrigation systems (in the Algerian Sahara) and become implicated in movements linking agricultural water to claims to political identity, land and citizenship (in the oGH, Syria).
- Bricolage arrangements are co-produced in the relationships between a variety of state/society actors, operating at intersecting scales.
- We question how far systemic changes wrought through bricolage are compatible with transformations to *ecological* sustainability.

Funding

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Notes

1. See Cleaver and Whaley (2018: 49) for a schematic characterisation of the political, cultural and socio-logical roots of bricolage thinking, also Mollinga (2019: 790) for a characterisation of different strands of critical water studies.
2. For elaboration of key features of bricolage, see Cleaver (2012: 33–52). For the location of institutional bricolage as a school of thought within scholarship on environmental governance, see Whaley (2022: 231) and Nunan (2019: 27–30).
3. A concern with scale as elaborated here raises interesting questions about study design and method. Addressing such questions is beyond the scope of this paper but they are beginning to be discussed in critical institutional thinking – see, for example, Liebrand (2015) and Whaley (2018).
4. Research and field work conducted by M. Naouri with the support of T. Hartani and M. Kuper, in Biskra between 2014 and 2019 and Ghardaia 2018–2019.
5. Landowners provide land and water, lessees provide greenhouses and financial capital, sharecroppers provide know-how and work force (in some cases, they hire labourers). Income sharing rules are generally as follows: Sharecroppers get 25% of the gross revenue (and pays the labourer), landowners 10%, and lessees get 65% (pays the rent of the land and water, the greenhouses and inputs). The risks are carefully distributed across the different actors. The sharecropper does not invest (although he pays the labourer) and the risk he takes is to have no or little revenues at the end of the season in case of plant diseases or volatility of market prices. The lessee encounters two distinct risks. First, and like the sharecropper, the risk of having little or no revenues, but second, he also cannot pay back his investment in greenhouses and drip irrigation if the season is not good. Finally, the landowner is paid by the lessee at the beginning of the season, independently of the success of the season. His risk is related to the investment (borehole, pump and water distribution network) as there may be breakdowns, in particular with the pump.
6. Fertigation is irrigation combined with the application of (soluble) fertiliser.
7. Phreatic aquifer is the first water table encountered in a permeable subsoil.
8. Albian aquifer is a little renewable deep groundwater layer where the pressure is higher than atmospheric pressure.
9. Fertigation is the injection of fertilizers into an irrigation system.
10. Large-scale greenhouses similar to the multi-span greenhouses.
11. Civil war in Algeria fought between the Algerian government and various Islamist rebel groups (1991–2002).
12. Research and field work conducted by Muna Dajani in Majdal Shams village in occupied Syrian Golan between 2015 and 2019.
13. Jawlani is a vernacular term referring to the Syrians of the oGH.
14. The oGH is a region south-west of Syria that has been illegally occupied by Israel since 1967. Today, around 25,000 Syrians (mostly of the Druze sect) live in five remaining villages on 7% of the occupied land and practice agriculture in order to remain on the land.
15. Mekorot is a wholly owned water company under the Ministry of Energy and Water and the Ministry of Finance.

16. Legislation authorises the Israeli Ministry of Agriculture to declare lands as 'waste' lands and to take control over 'uncultivated' lands (Cohre and Badil, 2005)
17. Jawlany.com (2019) The agricultural cooperatives in the Golan: clarification and explanation for the public on irrigation projects. Last accessed October 2022 from https://jawlany.com/-الجولان-في-الزراعية-الجمعيات/شرح-وتوض/
18. Ashtarr News (2004) The Golan opposes a plan to loot the waters of al-Musheirfeh. Last accessed December 2022. http://ashtarr.net/?p=5844
19. See also Okali and Sumberg (2012) on a similar story on tomato production in Ghana.

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