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Engaging with Flows: Embodied Cognition in Water Provision

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Abstract: This article provides an ethnographic example of a practice-based approach to water governance. It presents the situated case study of a *canalero* (canal operator) in the everyday water distribution of an irrigation system in Western Mexico. The canalero represents the low-ranked field operators at the frontline of many water provision organizations around the world, thereby providing a wider relevance to this case study. In spite of different waves of modernization that aimed to reduce 'the human element' and control water flows from a distance, canaleros still operate the manually adjustable gates and intakes in many medium and large open canal irrigation systems. Through a precise documentation of the daily routines of administering water, money, and data flows, anticipating shortages and mediating between conflicting demands, we conceptualize their semi-autonomous field of competent action. In contrast to a rule-based or normative approach to water governance, we will argue that the canaleros' cognition and competencies in mediating multiple resource flows are embodied and situated in specific social, technical and spatial arrangements for water provision. However, this field of professional competence is not clearly delineated and gets regularly contested in practice. The water operators deal with these 'problems of control', by drawing on their situational knowledge and embodied cognition acquired on-the-job. This case study outlines a framework for a practice-based and decentered study of water governance, focused on cognitive processes in water provision arrangements.

Keywords: water provision; practices; water governance; ethnography; embodied cognition; irrigation; water operators; canaleros; heterogeneous arrangements; bricolage

1. Introduction

The water provision and irrigation management literature has been heavily influenced by ideas from new institutional economics. Ostrom [1,2] analyzes water provision as a set of rules in use, generated by a community cooperative ethic and expressing a consensual equilibrium outcome of self-interested actors [3]. These rules produce behavioral incentives that reward and constrain the benefits and costs of irrigation officials and water users in the operation and maintenance of an irrigation system. So, rules and incentives are considered to provide the basic direction and energy for organizations to meet their stated performance objectives [4]. This type of neo-institutional analysis suggests that individual and collective organizational practices emanate from a rational response to coherent sets of institutional rules and incentives. The analytical weakness of this assumption lies in disregarding the considerable room for maneuver and agency that different social actors have, and the human competence and embodied cognition that these actors accumulate in dealing with these situations [5–7]. Consequently, such analysis fails to appreciate and analyze a diversity of existing and emerging forms of organizational practice.

To overcome these shortcomings, we propose an ethnographic and practice-based approach to water governance, which is apt to investigate whether robust and equitable rules of distribution and access govern resource access in the commons [8]. Using this approach highlights the importance of embodied and situated cognition of water operators, users, and managers in everyday water provision. The insights generated here are meant to be relevant for different water provision situations, but are acquired through the case study of water operators engaged in the everyday operation of irrigation systems.

In many medium and large scale open canal irrigation systems around the world with flexible and manually operated irrigation devices, a specialized cadre of low-ranked field personnel play an important role in scheduling and implementing water distribution [9]. In Mexico, this key actor who mediates the service relation between the irrigation institution and the water users is called the *canalero* (canal operator). Canaleros have co-constituted a semi-autonomous field of action in their infrastructural and organizational setting; an area of occupational or professional competence from which they derive a certain degree of authority.

An ethnography of everyday practices shows the implicit knowledge and meanings in human action and how these are also bodily, materially, and situationally anchored. This approach understands practices as: "meaningful, regulated bodily movements" [10] (p. 387), which depend on a tacit knowledge that is partially inscribed in bodies and artifacts; an embodied, distributed and situated cognition [11]. Cognitive science and artificial intelligence increasingly understand human cognition as not only situated in the mind, but also in the body in interaction with its environment [12]. Explicit or formalized knowledge, such as rules and norms, are of secondary importance in this approach.

Participant observation is a suitable research method to directly record bodily movements and interactions that do not necessarily involve speech [10]. Following the canalero in his everyday practices of mediating various resource flows, also allows documenting the sociotechnical arrangements involved. Additional research methods such as semi-structured interviews and document analysis together have helped to construct a situated case study of the canalero. Empirical observations were made during the period 1997–1999 and were informed by earlier observations in other Mexican irrigation districts. An earlier publication has reported this research and its wider relevance for irrigation and water governance [9]. The first researcher has since returned to the research site and other irrigation districts in Mexico, most recently in May 2019, which has re-confirmed the continued relevance of the observations and theoretical insights offered here. Detailed observations and ethnographic descriptions retain a fresh character and deliver a profound insight into everyday behavior and the role of embodied cognition. The case study of canalero Laguna was selected and constructed to illustrate and theorize how bodily cognition is situated and distributed in complex water provision networks. A grounded theory-like approach to data analysis helped to make sense of these varied empirical findings, infer theoretical principles and contribute to a preliminary analytical framework for a practice-based understanding of water governance.

The next section will review the relevant theory and outline a preliminary analytical framework to understand cognitive practices and competencies in water provision systems. The third section will introduce the background, after which the case study follows. In the fifth section we will present the analysis and conclusions.

2. Theory

In earlier publications we have provided elements that contribute to an analytical framework for a practice-based and decentered understanding of water governance [9,13]. This framework is relevant to other water provision situations and consists of four components associated with embodied cognition in water provision systems. We will elicit them below.

2.1. Water Provision Systems are Sociotechnical Arrangements

Water provision systems are sociotechnical assemblages of shifting human and non-human agents that spatially provide and differentiate access to multiple resource flows [14–17]. To organize the distribution of water, one not only requires human actors such as managers, operators, and farmers to follow certain operational rules, but one also needs to mobilize non-human elements such as a spatially distributed network of irrigation technologies, canals, drains, and fields, as well as engage with other resource flows such as money, information, planning sheets, etc. In the actual practice of water provision, we are never faced with either material objects or social relations; rather, the non-human and human are assembled into a heterogeneous actor-network [14,18–21]. The various elements that make up this arrangement are spatially distributed. The case of the *canalero* (canal operator) that follows below, and in particular his name, reveals an intimate bodily and cognitive relation with a specific canal infrastructure. Visual images of specific components of the irrigation technology and canal infrastructure that the canalero deals with in this case study are provided throughout this article (see Figures 1–4).

Figure 1. A sprinkler pump placed near an irrigation canal.

2.2. Heterogenous Arrangements Imply a Distribution of Competencies

Sociotechnical arrangements embody a distribution of competencies between humans and non-humans [22]. In water provision systems, these competencies are distributed between the specific infrastructure and the staff involved in operating and maintaining this network to provide water access to urban as well as rural water users. Even where water provision systems are designed and constructed to be centrally governed, they are often operated and maintained de-centrally by lower level operators with distributed competencies to do so. In the specific case of irrigation, the canalero produces a linkage between an irrigation institution and the water users, through a particular interpretation of his tasks and a professional competence. The canalero faces the 'canalero's dilemma': a situation in which he has to make constant choices between demands of his institutional superiors and farmers in the field, which are often mutually incompatible. A canalero solves this dilemma by acting and consciously shaping his working arrangements. Although the canaleros can be victims of their situation, they also have the possibility to counteract pressures from both sides. As an occupational group, they create

their own semi-autonomous field of action and have preserved it over several decades, in spite of several administrative and technological transformations [13].

Figure 2. A pipeline with sprinklers.

Figure 3. Pump operator carrying pipes.

Figure 4. The canalero near a cross-regulator and intake structure.

The canaleros distribute water from the main canal, via the lateral and sub-lateral canals, to the intake of individual farm plots. They operate the cross-regulators, sluices, and gates and are responsible for the weekly programming of water volumes that their sections require. At field level they are also responsible for scheduling and supervising irrigation turns for the farmers who irrigate their crops. Canaleros move around their area on motor bikes, ride along the canals, cross the fields and speed on the dirt roads. Although they are field workers, they do not simply execute guidelines received from above, but adapt them to the varying needs, constraints and demands experienced at field level.

In this article, we will emphasize the canalero's proficient and situation-specific knowledge of the infrastructure, canals, water flows, fields, crops, farmers and irrigators in the section where they are working. The canalero derives his professional competence and a degree of authority in decision making from his experience and knowledge of programming, adjusting gates and estimating water flows. Yet, there are clear limitations to these competencies. Firstly, the canalero's professional competence, embodied cognition and authority are not uncontested. This article will show that rules are regularly subverted, whilst the canalero has insufficient authority and sanctions to control fee default and water access. Secondly, a canalero's competence and cognition to control water and other flows is embedded in a 'cognitive ecology' [11], which consists of the specific social, material and spatial arrangements that are mobilized in water use practices [23]. Documenting this cognitive ecology, requires a meticulous and situated case study of the social, material and spatial arrangements in which canaleros operate and how they affect the embodied cognition of the canalero in question.

2.3. Water Provision Arrangements Engage Multiple Flows

A practice-based approach to water governance entails studying the organizing and ordering practices that allocate and intertwine multiple resource flows for the operation, maintenance and administration of water systems. A focus on water flows is obvious, but many other flows are actually engaged in and co-constitute the work of the water operator, such as: information, electronic data, paper forms, money, spare-parts, gifts, drinks, food, gasoline, motor bikes, etc. How these flows interweave and overlap puts certain cognitive demands on, and requires particular intermediation

skills from, the canaleros. Figures 1–3 suggest how water, gasoline, money and information flows are practically intertwined in irrigating with a mobile pump and sprinkler network, aspects which constitute the canalero's cognitive ecology, as we will see below.

2.4. Water Provision Networks Embody, Situate and Distribute Cognition

Cognitive processes in specific water provision arrangements appear as highly embodied, situated and distributed activities [11,23,24]. Much of the embodied cognition and competencies that a group of canaleros use on the job is acquired implicitly without the conscious intention to learn or awareness of having learned [25]. Therefore, in order to understand it we should address the tacit, implicit or sub-conscious dimension of such cognition [26–28]. 'The tacit knowing which shows itself in the intelligent action of a practitioner' is called 'knowing in action' [29]. It concerns the skills, tacit feel [27], or 'know how' of a practitioner. Elsewhere we have provided an illustrative example of canalero Miguel, whose situational and embodied knowledge of the precise effects of infrastructural manipulations on the velocity of water waves in a canal, proved more effective than the scientific calculations and assumptions of an engineer [9]. This relates to a kind of cognition that is implicit in the competent performance of a practitioner and that is not necessarily readily accessible as conscious rules. The canalero will demonstrate in his practices a tacit knowing or feel, which he has acquired largely through 'learning by doing' and on-the-job-training. Nevertheless, this cognition is not just individual, but can be distributed and partly transferred among a group of professionals.

Many studies tend to focus on central ordering sites or centers of calculation such as laboratories, offices or control rooms, with the implicit and dormant idea that this is where cognition emanates and is situated [10,14]. Also, studies of lower level bureaucrats, frontline workers, or field workers of large bureaucracies have traditionally focused on the 'modern', institutionalized and spatially circumscribed workplaces that are typical of urban bureaucracies, factories, or laboratories [7,28,30]. Such workspaces are characterized by a high degree of social, material and spatial standardization and homogenization and therefore require a relatively standard set of disembodied competencies from the worker in question. The homogenized and ordered nature of the work environment and the control over incoming and outgoing flows of clients, files and resources are easily taken for granted. All engineered conditions place a frontline worker at the center in order to function as an 'obligatory passage point' [14]. Yet, when we follow the water operators' everyday practices, we investigate 'cognition in the wild' [23], embodied in mobile actors, who are constantly moving about in order to mediate between specific arrangements of social actors, physical structures and resource flows.

3. Background: The Left Bank Irrigation District and its Operational Sections

Medium to large irrigation districts that were constructed by the Mexican hydraulic bureaucracy during the twentieth century were publicly administered in most cases. However, since the neoliberal water reforms of the 1990s, these open canal irrigation systems are managed by Water Users Associations (WUAs), in which mixtures of public, private and water users' interests intersect [31,32]. The General Assembly of water user delegates elect a directive board, which employs managers and field personnel for service provision. On the Left Bank of the River Santiago Irrigation District in Nayarit, two operational rules are crucial for orderly water distribution and timely irrigation fee payment. The first rule stipulates that a water user must request an irrigation turn a fixed number of days in advance; the second rule requires water users to pay their irrigation fee before receiving the first irrigation turn.

The Left Bank is in the fortunate situation of having no absolute water scarcity. If everybody stuck to the rules, they would all receive sufficient water on time. Water availability here is thus not the kind of problem that it is in most other irrigated parts of Mexico. Hence, the volumetric water price and the irrigation fees are relatively low. In addition, the Left Bank irrigation infrastructure allows for flexible water allocation. This would appear an ideal point of departure for a Water Users' Association

to establish an orderly water distribution and financial self-sufficiency in line with the established operational rules.

Instead, we encounter a slightly chaotic and sub-optimal situation in which water distribution is far from efficient, plots are sometimes flooded, 'free riders' take water without paying fees or requesting an irrigation turn, and farmers do not receive their irrigation turns on time. Furthermore, a group of well-connected large producers enjoys privileged access to water. These 'problems of control' in the distribution of water introduce a relative scarcity of water. As a result, the equality, convenience, reliability (predictability) and timeliness of water distribution to individual farmers is problematic [33], particularly towards the tail-end of the system. In addition, the collection of irrigation fees is not a straightforward task. However, the situation could be more dramatic if it were not for the competent role that the canaleros play in partly resolving these problems.

A map of the Left Bank irrigation system shows its division into thirteen operational sections (see Figure 5). A section consists of a part of the main canal and various minor canals, and its boundaries generally are larger collector drains. On the map, it is basically a geographically bounded spatial arrangement of irrigation canals, drains, and fields. These sections are heterogeneous spaces, as they contain diverging collections of farmers, crops, plots and field irrigation technologies (see for example Table 1), i.e., the specific social and material aspects of irrigation and agriculture in each section. The differences between these workspaces generate distinct patterns of water demand and distribution and therefore influence the work of a canalero and the competencies that he requires. To illustrate this, we will mention just a few obvious contrasts between the sections that have implications for water distribution: head-end vs. tail-end location (high vs. lower water availability and reliability), smaller *ejido*, plots vs. larger private landholdings (small vs. large volumes), tobacco vs. rice production (small volumes but unpredictable in timing vs. standard water allocation per time unit), and the operational arrangements involved in sprinkler and surface irrigation.

An organizational chart of the association indicates that the general manager is responsible for the operation, maintenance, and administration of the irrigation system. The actual water distribution and the registration of water fees in the field are undertaken by a team of seven canaleros. Although the manager is formally responsible, in practice he is hardly involved and leaves the daily distribution to his subordinate, the supervising canalero. This experienced canalero supervises the work of the other six canaleros, who are each responsible for two sections. Further, he operates the most upstream section of the irrigation system. From there he can also monitor the incoming discharge into the main canal and co-ordinate adjustments with the *Comisión Nacional del Agua* (CONAGUA—before CNA: National Water Commission) at the dam. He stays in contact with the CONAGUA district on a regular basis for the daily water requests, weekly programming, and monthly reporting.

The manager does not carry out the annual irrigation planning, since it has a limited influence over daily water distribution, but rather, he leaves this to the local CONAGUA supervisor. The manager appears to have limited experience and interest in the field of water distribution. The supervision of the supervising canalero is also limited, which means that the canaleros have a degree of autonomy in distributing water in their sections. Occasionally the manager organizes a meeting with all canaleros to discuss operational issues and the progress in fee collection matters.

The canalero's central activities are water distribution, fee administration and information brokerage. An examination of the relevant official rules of conduct concerning these activities starts with the by-laws of the Left Bank WUA. The Concession Title establishes the legal terms for the concession of the infrastructure by the government to the WUA. It is a formal document produced by CONAGUA that was signed at the time of official transfer of management responsibilities from the government to the users. This document includes the operational instructions for the association. According to these instructions, water distribution is carried out on the basis of 'weekly demand'. The instructions state that a water user has to request an irrigation turn before the end of the week from his canalero to be able to irrigate during the next week. The canalero collects all these irrigation

requests and passes them on. On this basis, the manager is able to program the water needs for the thirteen sections for the period of a week.

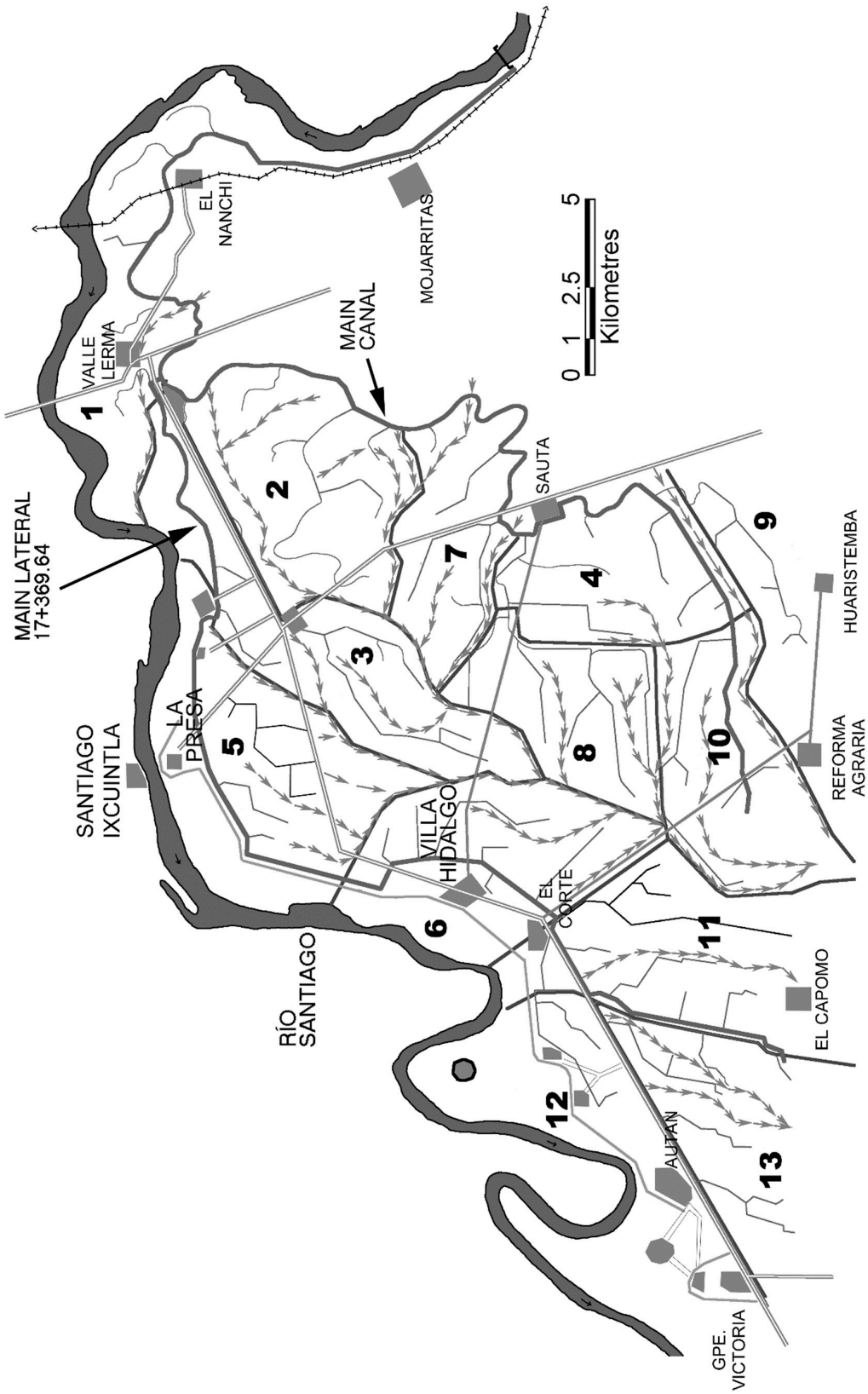

Figure 5. Operational sections of The Left Bank.

Table 1. Sections 3 and 5 in Autumn–Winter 1999.

		Section 3		**Section 5**
Landholding pattern (hectare)		1440		1821
Private land (%)		38		4
Ejidos (%)		62		96
Number of producers		224		541
Private land holders (%)		5		1
Ejidatarios (%)		95		99
Cropping pattern (ha)				
1.	Pasture	277	Tobacco	900
2.	Rice	132	Beans	75
3.	Sorghum	99	Sorghum	37
4.	Tobacco	55	Jicama	33
5.	Beans	28	Tomatoes	26
6.	Other crops	30	Perennials	23
Irrigated area (ha)		621		1094
Number of irrigated plots		75		421
Average irrigated plot size (ha)		8.3		3.1
Irrigation technology (Percentage of area):				
- Sprinkler irrigation - Surface irrigation		16, 84		95, 5
Irrigation fee agreements potential * (%)		51		93

Source: Overview irrigated crops and irrigation plan, Association, 1998–1999. * This is the percentage of hectares of a section that potentially falls under financial agreements to pre-finance the fee.

The canalero releases the programmed discharge from the main canal or main lateral into the sub-laterals and lower level field canals. He does this by backing up the water in the main lateral to an adequate level by means of adjusting the radial gates and the intake structures. Subsequently, he monitors whether sufficient water is flowing through for the number of irrigation turns programmed along a particular canal. When the canalero has opened a field intake or authorized a farmer to take a turn, his responsibility ends. The farmer is expected to take over from here at the agreed time and to irrigate his field for an agreed number of hours or days. The canalero carries a field notebook in which he registers the dates of the delivered irrigation turns. This booklet allows him to check the number of irrigation turns that a producer has had, to report on all the irrigation turns and water volumes allocated. These reports are gathered on a monthly basis and submitted as a report by the supervising canalero to the CONAGUA.

In actual field practice, the canaleros themselves often refer to a period of three days' notice in contrast to the official weekly planning period. However, it often happens that water users do not request an irrigation turn from their canalero, but take the water without his permission. The canaleros are confronted with the practical difficulties of refusing irrigation turns to those water users who bypass them. This makes the actual water demand an unpredictable factor, as it is only partly expressed through administrative planning procedures. It also in part responds to a decentered field dynamic that is difficult for the canalero to control. During the week, the canalero therefore occasionally has to adapt his weekly planning and demand less or more water for his sections. When this is the case for several sections, the WUA sends a request to CONAGUA to alter the total discharge from the dam.

Before starting to irrigate, water users have to pay a user fee per hectare of land to be irrigated. Formally, they require an irrigation request form from the canalero stating the crop and the number of hectares that the user wants to irrigate on a particular plot. With this form, the user has to go to the WUA office and pay the respective irrigation fee, which is a fixed rate per crop for every irrigated hectare. In return he receives an irrigation permit. These receipts again have to be shown to the

canalero in order to irrigate for the first time. According to the Concession Title, the WUA is not allowed to allocate water to a user who has not paid his fee. The WUA depends on the canalero to correctly register the irrigated area and to enforce fee payment.

In spite of these rules, fee default remains a major problem for the WUA. The WUA does not have effective sanctions to discipline free riders who take irrigation turns before or without paying their fees, or to exclude them from access to water. The most effective means to counter fee defaulting are financial agreements with multinational tobacco enterprises involved in irrigated production. The tobacco companies advance the irrigation fees of their tobacco producers to the WUA and deduct these expenses before the final disbursement of these farmers' profits. This secures a significant part of the WUA's annual fee collection.

Besides their formally prescribed tasks, the Left Bank canaleros perform other activities and roles in line with their intermediary position. For a majority of users, the canalero is the only representative with whom they entertain some kind of relation and encounter with some frequency whilst in the field. Many *ejidatarios* (members of ejidos) only go to the office of the association in Villa Hidalgo when they have to pay their fees. They have no relation with the association's board or management, or their ejido delegate. The canalero is an important source of information for them regarding, for instance, irrigation fees or crop subsidies. When the canalero is driving through the fields, he is easily approachable with regard to questions and complaints that users want to direct at the association. In addition, the canalero sometimes acts as a sort of agricultural extensionist or technical advisor for some producers.

For the board and the group that controls the management of the WUA, the canaleros also fulfil activities that by-laws do not define. The canaleros are their 'eyes and hands in the field', a means through which they are able to act from a distance. Their usability and mobility in the field and accessibility from the office are greatly enhanced by the canaleros' radios and motor bikes. They are put into action for a variety of purposes, which occasionally have little to do with their job. For example, the canaleros have to assist with organizing public meetings for the association or political meetings and electoral events for the group that controls the WUA. They help to arrange the chairs and distribute food or drinks [34].

4. The Case Study of a Canalero

4.1. Life History and Professional Experience

Laguna is a relatively young canalero of 32 years of age from the village of Villa Hidalgo. He recently married Delia, aged 23, who is also working for the association, as a secretary. They live just a few blocks from the office. He takes his work very seriously and actively considers the prospects that he has within the association as a canalero with an agronomy degree. Although he likes a beer, he refrains from drinking and going to the local *cantinas* and accepting beers, food or gifts from water users in exchange for water. This is perhaps why his body is still relatively lean compared with some colleagues. Like most colleagues and several farmers in the field he wears a baseball cap of a seed company, sunglasses, t-shirt, jeans, a radio on his belt and boots for the mud. Consistent with the rural setting, this canalero maintains a moustache.

In 1993, Laguna started working as a canalero for the association. The first period he experienced as being very difficult. Originally, Laguna was supposed to be trained by one of CONAGUA's ex-canaleros, Juan. However, when he arrived it appeared that all the old canaleros had already left. As mentioned above, only two CONAGUA canaleros with more than a decade of experience continued to work for the association, one of whom became the supervising canalero. However, they did not have a clear role in Laguna's training either. Laguna recalls that he went to the field for the first time with another canalero who was fairly inexperienced himself. He remembers that, that same day, he was sent by this man along a lateral canal with the instruction to go and watch, without any further guidance. As he was driving along the canal on his motor bike, farmers came up to him asking him for water.

He did not know anything and had no idea of what to do. So he started giving water to these farmers and adjusting the control structures. It was very stressful and created many tensions for him.

During his first weeks he made many mistakes, because he had nobody to show him what to do or how to solve a particular problem. On several occasions, this resulted in angry farmers demanding water, or accusations from his colleague canaleros that he was using too much water, leading to unpleasant bodily interactions and stressful situations, which he later learned to overcome. 'Theory is not like practice', he states, indicating that the formulas and concepts that he learned during his formal education and the special CONAGUA training course were hardly useful for doing the work of a canalero. He learned slowly by actually distributing the water, by trying out different things and also by observing and interacting with his colleagues and irrigating farmers.

4.2. Sections as a Heterogeneous Work Space

For the third year, Laguna is working in the relatively upstream Sections 3 and 5 of the irrigation system (see Figure 5). These are contrasting sections in terms not only of the type of land ownership, farmers, cropping patterns and field irrigation technologies, but also of plot size and the number of farmers to whom he has to distribute water (see Table 1). Here we mainly focus on Section 5 (see Figure 6), which is one of the largest and most demanding workspaces for a canalero, as it is dominated by small-scale tobacco production and sprinkler irrigation. We concentrate on how the canalero deals with the specific problems, demands, and complexities of the heterogeneous arrangements involved in sprinkler irrigation.

Section 5 includes more than 1000 hectares of actually irrigated land and more than 500 tobacco producers. Most of the land belongs to the ejido of La Presa, which is the largest tobacco producing ejido in the region. The tobacco cultivation is undertaken by hundreds of small-scale producers. The extremely fragmented pattern of land distribution and ownership is even further complicated by the large-scale leasing of land for the production of tobacco. On average, the irrigated tobacco plots are three hectares. This contrasts sharply with, for example, Section 3 that typically contains much larger irrigated holdings of approximately eight hectares. In other sections the ejido plots also tend to be larger (on average four hectares). For the canalero, the daily water distribution and fee administration in a big section with a large number of plots and producers involves a huge workload.

Getting to know the many people in his section has taken Laguna several years. After three years, he knows hundreds of producers, *bomberos* (pump operators), irrigators and other villagers who are involved in the production of tobacco. Laguna deals with most of the irrigating farmers and bomberos that he encounters in the field in a friendly and respectful manner and he tries to prevent or mediate conflicts with them. Occasionally, he advises farmers on organizational or agronomic matters, gaining some respect from them.

Section 5 is an economically and politically important space for the association's management, because of the political and institutional importance of tobacco and the fact that some leaders and some of their clientele, allies and friends are based here, particularly among the ejido commissioners and delegates of the association's assembly. For the association, the financial importance of Section 5 exceeds that of many other sections, because its fee collection potential is much higher (see Table 1).

In order to bank these revenues, Laguna needs to connect the WUA's administration with that of the tobacco companies. This involves the complicated task of linking an official, but outdated, CONAGUA list of water users and plots with a list of registered tobacco producers that often do not coincide. The companies transfer the irrigation fee for individual tobacco producers, who are organized in groups, only when they receive a group leader's signature to confirm that they are receiving water. To get this signature and find out which plots a tobacco producer is using and to which water user this corresponds, the canalero needs to visit all group leaders in his section. This is a very labor-intensive task and requires an intimate knowledge of the multitude of plots, ejidatarios and tobacco producers in Section 5. The association receives a periodic payment in respect of lists completed by the canalero.

The management thus pressures the canaleros in tobacco sections to make haste with this activity. The canaleros in their turn complain about the various demanding tasks that they have to fulfil.

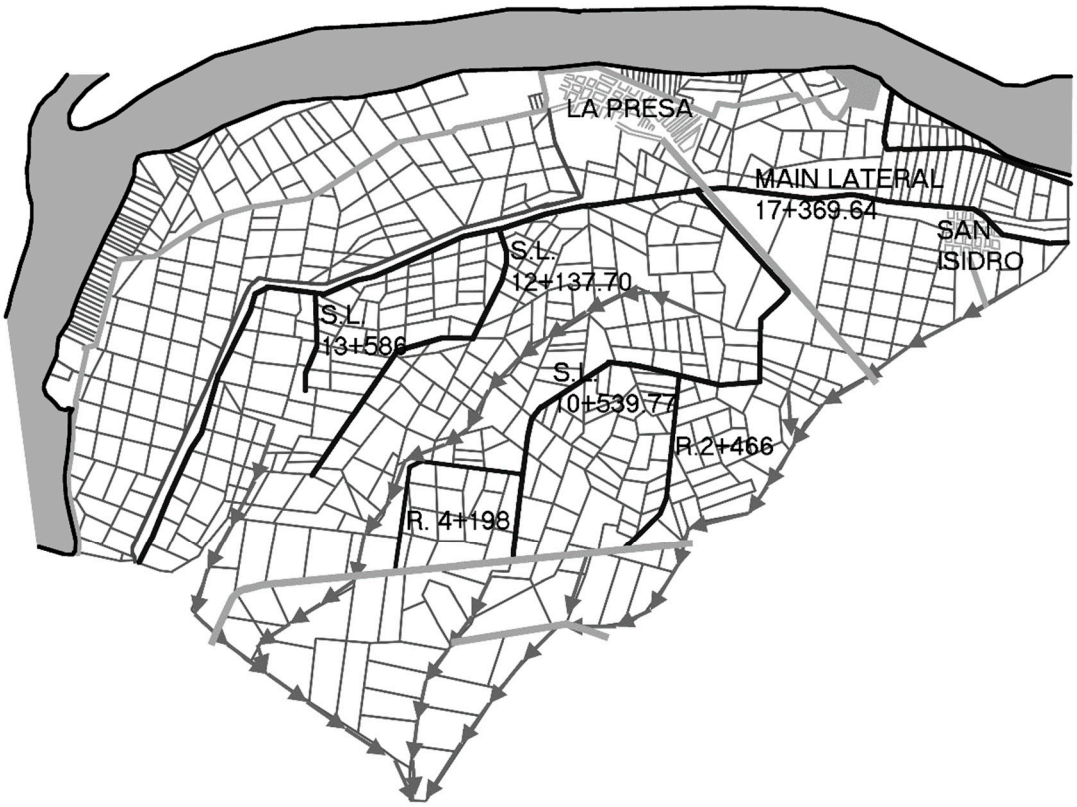

Figure 6. Section 5.

4.3. Sprinkler Irrigation in Tobacco Production

The prevailing irrigation method in Section 5 is sprinkler irrigation. As in other parts of the Northern Coast, it is considered the traditional form of irrigation. Initially, tobacco companies introduced the first pumps and mobile sprinkler systems to the region in order to irrigate the lighter tobacco varieties. After the nationalization of the tobacco market at the beginning of the 1970s, the parastatal, Tabamex, started to intervene in almost every phase of the tobacco production cycle [35]. Amongst other things, it arranged the irrigation of tobacco plots for thousands of tobacco producers in the region according to a complex scheme. This further increased the use and the number of sprinkler systems. Specialized staff, sprinkler installations, and other means and resources were allocated for this purpose. Most tobacco producers thus never experienced the need to buy a system for themselves, in spite of their sometimes significant profits. In addition, they gained little experience with the actual irrigation practice themselves. Tabamex staff and the additional private owners who rented out their installations determined the timing of irrigation turns.

Within this institutionalized set-up, individual tobacco producers had no need to request an irrigation turn and therefore failed to develop a routine. This situation remained largely the same after the dismantling of Tabamex in 1991. The tobacco companies who became active in the area decided to decentralize the costly and labor-intensive task of irrigation to their tobacco producers. They started giving out loans to the producers to buy a sprinkler system. However, most small-scale tobacco producers were not sufficiently profitable to qualify for such loans. Therefore, these farmers hired sprinkler systems from more well-to-do farmers, and the companies started pre-financing this for five irrigation turns per cycle. The high cost of this is paid for by these farmers at the end of the season. In addition, the companies started advancing the irrigation fees of their tobacco producers

to the WUA. As a result, these producers developed no need to interact with either the WUA or the canalero to get permission for irrigation and learn about their operational rules.

This institutional history clarifies the particular distribution of assets, competences and costs that determines the current irrigation practice. Most tobacco producers thus have to look for a fellow farmer willing to rent out a sprinkler installation to them every time they want to irrigate. Often they try to find somebody close to their plot, or from their own village. These scarce installations have thus become the critical link around which irrigating farmers organize their access to water.

The owners of a sprinkler installation normally employ a bombero and, sometimes, additional *regadores* (irrigators) as laborers. The sprinkler systems used in this area can be characterized as periodic-move systems or, more precisely, hand-moved lateral systems [36,37]. The (non-human) components of these systems consist of a diesel pump with a capacity of forty liters per second, a temporarily fixed main line and hand-moved laterals, which transport the water under a certain pressure to the connected sprinklers. The bombero is responsible for installing, operating and maintaining the pump. Together with the other irrigators, he connects the pipes to form a main line and a lateral. After a few hours, when a track of land has been irrigated, they move the lateral a few meters to irrigate the next bit.

The owner of the pump, and also the bombero and his irrigators, are paid per hectare. This encourages them to irrigate rapidly and not to lose time in order to cover a greater area in a week. Particularly at the height of the irrigation season from November to March, a bombero earns a salary that is significantly higher than that of an ordinary land laborer. Many plots need to be irrigated, and the pumps, sprinkler systems and their operators are in high demand and are moving from one field to another. The owner of the pump can basically rent it out to anyone he wants. In order to bring the necessary components together to get his land irrigated, a *tabaquero* (tobacco producer) is thus very dependent on the timing, quality and financing of work by others. Many small-scale tobacco producers thus play a limited role in the actual irrigation of their crops. They only have a rough idea when the bombero and the sprinkler system will arrive to irrigate their field, and all they can do is wait for that moment. It has never been an established practice among these tobacco producers to request an irrigation turn from the canalero, and it is also difficult in practice for them to request it three days in advance, because the timing of their irrigation turn is dependent on the availability of the sprinkler system.

In practice, when the bombero arrives with the whole installation at a field, he immediately starts installing the pump and throws in the '*pichancha*' (intake pipe), if there is sufficient level in the canal or drain from which he intends to draw the water. The latter is usually not a problem in this section, especially at the head-end of canals. The bombero does not await the consent of the canalero or the tabaquero, neither of whom in most cases is present at that moment. A bombero basically does not need the canalero to give him access to water, because he can easily physically bypass him with a pump and an intake pipe. For them, this is simply the shortest and most time saving link to water. The canalero is in this case therefore not the most essential intermediary; what is more, his capacity to monitor pumps along a canal is limited. Irrigating farmers whose fields are located towards the tail-end or near a drain, where the delivery of water is more irregular or insecure, are more likely to inform the canalero. When there is no water available, it sometimes happens that angry farmers or bomberos blame the canalero for not allocating sufficient water.

The following section focuses on Laguna's work of distributing water under this kind of operational arrangement, bringing to the fore the particular problems of control, contradictions, and complexities that he has to resolve in his daily practice.

4.4. In the Field: Driving Along 'the 10'

In spite of the overall abundance of water, the canaleros unanimously agree that the head-end of Section 5 is one of the most difficult and demanding sections. They measure the difficulty and the workload of this section by the number of sheets Laguna requires for the programming and reporting

of irrigation. When I asked him about Section 5, he demonstratively waves in the air six or seven reporting sheets that he has painstakingly filled out. He stresses that some of his colleagues can suffice with only one or two pages per section. His weekly programs and monthly reports require much work, because of the large area, the large numbers of irrigating tobacco producers and their plots that have to be registered. This gives an indication of the amount and intensity of his work, and his long working days. It requires enormous flexibility on the part of a canalero to ensure that the available water supply in the main canals satisfies real demand in the field.

When I joined Laguna in his work in February 1998, still at the height of the main irrigation season, he departs from his house on his motor bike in the early morning. He works until the late afternoon, with an interruption at lunchtime. Most of the day he can be found in the field, but in the afternoon he sometimes needs to check an administrative matter with one of the secretaries or is called to the office via the radio by the manager.

At this time of year when many farmers are irrigating, Laguna needs to make frequent adjustments to gates and intakes in the main canals, laterals, sub-laterals, and lower level canals. This often determines his route through the sections. He has to return two to three times a day to check the level in the canals. Especially when an additional amount of water for the tail-end sections has been let into the main canal, he has to ensure that the radial gates in the main lateral are adjusted so that this extra volume arrives in the downstream sections. As an upstream canalero, he can be easily accused by his downstream colleagues of using the water that they requested for his own sections. From the main lateral, Laguna normally drives downstream along the sub-laterals and minor canals, where he checks the running irrigation turns and the water levels in the canals, while adjusting some gates. Meanwhile, he observes and talks to farmers, pump operators and irrigators, and other people that he encounters or seeks out in the field. Laguna alternates easily between opening gates and searching for particular tobacco producers who need to sign an agreement for him.

The sub-lateral 10 + 539.77 of the lateral 17, called 'the 10' by the canaleros, is about five kilometers long and has three sub-laterals (see Figures 5 and 6). It is equipped with nine cross-regulators and thirteen direct field intakes. This canal presents several of the control problems that Laguna is experiencing in distributing water in this section, but in an even more intense way. This canal, its laterals, and the drains connected to it irrigate more than 100 small plots, owned by a similar number of ejidatarios. On several occasions, Laguna emphasizes the complexities and unexpected situations he encounters on this canal.

Early one February morning, Laguna and I drive towards the intake of the 10 on the main lateral, near a crossroads just outside the village of La Presa. Arriving there, we meet the local CONAGUA supervisor. We stand close to a cross-regulator in the main lateral, which backs up the water level to a height that ensures that sufficient discharge flows into the 10. The CONAGUA supervisor comments to Laguna about the water in the main lateral being backed up to a very high level. The water is even flowing over the spillway of the cross-regulator, which is meant only for an excessive flow, such as occurs, for example, during a rainstorm. The supervisor is worried that, as a result, the downstream canaleros will not receive their requested volumes on time. Laguna responds that the situation is more complicated than the supervisor thinks. His aim is to maintain the water level exactly at the height of the spillway. He has to do this in order to cover the whole of the 10.

According to Laguna, the canal is badly constructed. It runs 'in reverse'. The intake of the canal is much too high and the canal does not have a gradient. Moreover, the end reach of the canal even goes up slightly. If he lowered the water level in the main lateral by just twenty centimeters, this would mean that the water flow would not reach the end of the 10. He would come into serious conflict with the tail-enders of the canal and those who use the tail water from the drain connected to it. His solution anticipates the water demand of these tail-enders, although some of them irrigate land that lies far away from a canal and several have not requested an irrigation turn. Damming up the water level at this point of the main lateral is a tricky business for Laguna, not least because it also affects the downstream water distribution of other colleagues, because they may receive their water later than

requested. Laguna claims to have learned to deal with this infrastructural defect in this way through his experience of experimenting with water levels, adjusting the cross-regulator, and distributing water among these tobacco producers. The canaleros face similar problems with other sub-laterals.

When we arrive at the 2 + 466 (a sub-lateral of the 10), Laguna points to two pumps placed on the road next to the 10. According to Laguna, he found these pumps working this morning without being apprised of the fact that these tobacco producers were planning to irrigate. In addition, two other pumps were placed on the drain connected to the 10 into which water is released. As we drive along the 2 we encounter another two pumps that are irrigating. Although several of these pumps were not specifically programmed by Laguna, he estimates that the present flow in the 10 will be sufficient for the six pumps that he has observed. In his program of last week and in determining the actual inflow for the 10 this morning, he deliberately took into account the fact that some pumps would unexpectedly appear on the canal and consume an extra flow. He programmed and allocated water for a few additional pumps. However, sometimes this precautionary measure is not enough. Then he requests an additional amount of water for his section. The supervising canalero coordinates these mid-weekly requests with the dam.

The total number of pumps on a canal thus determines the actual water demand. But Laguna never has an exact idea of how many pumps will be placed along the canal during a weekday. Admittedly, the pumps only consume a limited and predictable water flow (40 L/s). However, it is not the individual water demand but the unpredictability of the number of working pumps that creates problems for him. It can happen that from one moment to the next, suddenly around ten pumps are placed on the canal, whereas only three or four farmers have forewarned him. The over-consumption causes the water level to drop rapidly, as a result of which the farther downstream tobacco producers cannot irrigate. Meeting the rapidly increased demand immediately with the available supply of water becomes problematic. As a consequence, Laguna is confronted with angry downstream farmers who want to irrigate at once, because they have hired a sprinkler system and risk the bombero going somewhere else first, when they cannot irrigate right away. In spite of the fact that most tobacco producers along this canal come from the ejido of La Presa, there is limited mutual social control on having the permission of the canalero to irrigate. This is caused partly because the actual irrigation is carried out by bomberos, who can easily dodge agreements, operational rules and the canaleros' authority. Getting the canaleros' permission is simply not their concern. The following day it can just as easily happen that Laguna finds only a few bomberos irrigating at the canal, with the result that the allocated water flow runs idly towards the ocean.

According to Laguna, the unpredictability of the water demand requires him to regularly monitor the number of pumps along the whole length of the canal. To review the situation in the event of problems, he needs to check the whole sub-lateral and not just the field intakes, because the bomberos basically start irrigating wherever and whenever they want to. At the height of the tobacco season, he passes along the 10 at least twice a day, and sometimes even more often, in order to check on the water level and make revisions when necessary. These decisions are largely tacit, based on Laguna's implicit knowledge and experience with this canal and its dynamic water demand. It is also not in his interest to make such decisions explicit, as they can be very conflictive. He is well aware of the impact they might have downstream, i.e., the lack of water for his downstream colleagues, but that is not his immediate concern. He is not directly confronted with the angry farmers who have planned an irrigation turn but do not receive it on time. The only thing to bother about is his downstream colleagues who are accusing him of taking too much water. His response to that is generally evasive.

I ask Laguna what he does with farmers who do not inform him on time before starting to irrigate. According to Laguna, he tells them that the next time they should inform him. However, being in the field with him, I witness nothing of the sort. Moreover, in the days I spent with Laguna I have never seen him reprimanding a farmer about an irrigation turn that was not requested or not on time, in spite of the fact that he frequently complains about the difficulties that this presents to him. His busy daily schedule keeps him from reprimanding tobacco producers and bomberos for breaking

this operational rule. In addition, applying a sanction is not really an effective option for Laguna. He claims to have told people over and over again to inform him if they want to irrigate, but that it has had little result. The same farmers continue to irrigate without his permission. Reprimanding has only produced conflicts with farmers and bomberos, which he prefers to avoid. Laguna seems to have accepted the situation that he is often bypassed and does not have effective control over the actual water distribution.

But why does Laguna not use sanctions such as imposing a fine or sending for the hydraulic police, which is a special police department in Tepic, the state capital, for these matters? He responds that if he took such a measure the manager would immediately rescind it. Last year the hydraulic police finally visited the system. This visit was one of the few times that they came to the Left Bank. They removed an intake pipe of a farmer who had not yet paid his irrigation fee. Removing an intake pipe from a canal is something that the management often talks about and that the canaleros threaten with, but in practice it hardly ever happens. In this case, the only thing the manager did the next day when the police had left was to give this man his pipe back without any reprimand. This example backs up Laguna's argument that the canaleros do not feel supported by management. On several occasions, his superior has undone his decisions or simply bypassed him. Such actions demotivate him from enforcing this particular operational rule.

Near a cross-regulator in the 2, I notice that the water is backed up close to the rim of the canal. I ask him why. Laguna responds that he did not cause this. Some farmers must have let the gate down during the night because they wanted more water. Laguna has not given them permission to do this. He rectifies the situation by bringing the gate up. Although he acknowledges that people have transgressed the operational rule that they should receive his permission, he does not take any further action. He seems used to people contesting his authority by moving structures without his permission. On other occasions, it seems that somebody moved a gate without an obvious motive, perhaps some boys who crossed the structure to get to the other side of the canal. When Laguna finds that people have moved a gate, he responds by returning it. In the case of repetition or when he suspects a notorious farmer, he may use a lock or make a remark to bystanders or particular farmers. However, it is often difficult to prove who moved the gate, and Laguna argues that it is not in his interest to create conflicts by accusing people, falsely or otherwise.

4.5. Time to Reflect: A Former Canalero on the Scene

In the shadow of an old *guamuchil* tree, close to the 10, Laguna discusses some of his work-related problems with an ex-canalero. Juan worked as a canalero for twenty years and retired soon after the transfer of the irrigation system. When I ask him what has changed in the work of the canalero, he responds that very little has changed. It is true that the canaleros are more technologically advanced nowadays, being equipped with radios and motor bikes by the association. Laguna adds that the canaleros presently manage two sections and therefore a larger irrigated area. Juan says that the other day he witnessed the flooding of a plot, which was caused by farmers who had moved a gate without the canalero's permission. This also frequently happened in his days. Another thing that remains the same is that they also told producers again and again to request water on time, but that this did not change a thing.

Laguna seems to agree with the elder, experienced man. He argues that when he tells users to wait for their turn, somewhat later he receives an order from the office to give them water. 'They take away my authority', Laguna states. When he tells farmers that they have to wait before they can irrigate, they go to the association and ask if they can get water directly. The association's president and manager give in to such requests because they have commitments with these farmers, or because they are engaged in a political campaign and thus in need of support. Therefore, as canaleros, they do not feel that the manager supports them. He claims not to be able to do anything, because the next time these farmers laugh in his face.

'*Mejor sigues la corriente*' (It is better to follow the flow), the ex-canalero concludes. For a canalero it is better to give in to certain pressures that he faces, rather than resist them. Some producers develop special relations with the office, the former canalero confides in me. The canalero cannot prevent that, he opines. This was the case in the past and will not change in the future. Following the flow means that the canalero cannot always regulate the flow and control access to it. It certainly does not imply mere passivity, but it does warn against romanticization.

5. Conclusions

In this article we argue that the cognition and competencies of water operators in mediating multiple resource flows are embodied and situated in specific social, technical and spatial arrangements for water provision. The article seeks to contribute to a practice-based approach to water governance.

Operational rules in water provision practices and the authority to impose them are regularly subverted. This situation is similar to many water governance contexts in which enforcement is problematic [38], yet the surprising matter here is that the canalero's competent mediation avoids potential disorder. Instead of depending on formal allocation rules, the canalero acquires a detailed knowledge of the idiosyncratic, unpredictable and heterogeneous features of the sections in which he works and the complexities involved in water distribution. In part, this occurs through implicit and on-site learning in the course of his work. To become competent in a new section takes time, as the first hectic experiences of Laguna along the 10 illustrated. Over time, this experience taught him bodily and cognitive competencies, such as how to maintain a water level in a canal, anticipate and respond to the unpredictable water demand, interact with a variety of irrigators, pump operators, tobacco producers, and landowners, and negotiate between the conflicting demands of 'water users' and his managerial superiors. (The latter variety raises the question: 'who is the water user?') [39].

By describing the canaleros' everyday practices, we have visualized a semi-autonomous field of competence in water provision at field level. The canal infrastructure with its adjustable gates and intakes appears a complex system to manage and this is even worsened by the unpredictability of water demand for tobacco under sprinkler irrigation. However, this infrastructural flexibility allows the canalero to competently use canal infrastructure and respond to diversity in crops, plots and water demand. The particular form of the technical infrastructure influences the water distribution but does not completely determine it, because the canalero has 'internalized' the social, technical and spatial properties of the system. The immediate cognitive and bodily responses to infrastructural and technological contingencies which the canalero demonstrate, do justice to his name which reveals his intimate relation with the canal infrastructure.

The water operator's competence is embedded and contested in concrete social, material and spatial relations that constitute a 'cognitive ecology' [11,23]. Laguna's experience became evident in his dealing with the specific combinations of sprinkler irrigation and small-scale tobacco production. First he experienced, and then had to learn how to deal with, its complexities. Even so, this does not imply that this type of cognition or the learning process is purely personal and that it cannot be exchanged or transferred. There is significant overlap in the canaleros' experiences with crops, irrigation technologies, farmers on the Left Bank; and most canaleros have worked for some time in other sections. The kind of embodied knowledge that the canaleros possess is situated and shared in an occupational group. In future publications, we will argue that this embodied cognition in water provision is highly gendered, as this case also shows.

The canalero's competence lies precisely in actively dealing with the 'problems of control' in his sections and in curtailing their negative consequences. He has learned to anticipate the unpredictable water demand and respond to the social and technical difficulties of distributing water. For instance, at the height of the tobacco season, he constantly moves his motorized body about to monitor the water levels in the canals, adjusts structures and water flows accordingly, divides water on the spot, negotiates with farmers, sometimes tells them to await their turns, or he requests more water from the dam, when this is needed. In addition, he anticipates particular problems by programming more

irrigation turns than strictly required, in order to have sufficient water in case of unannounced irrigators. By symbolically attaching locks to inlet structures, he prevents farmers from taking water or causing floods. He also avoids conflicts over water and takes care that the water requested by tail-enders really reaches the tail-end.

This ethnographic case study has contributed to outlining a preliminary framework for a practice-based and decentered study of water governance, focused on cognitive processes in water provision arrangements. Figure 7 summarizes this framework. We invite readers, and hope to inspire practitioners and researchers, to explore its use and adapt it to other water provision arrangements, for example in drinking water and waste water management. We are also interested in the question of how cognitive practices change among water operators, professionals and users, when their cognitive ecology changes. In this case study, sprinkler irrigation transformed and diversified the water provision arrangements. Currently, the pervasive pipelining of water-networks and the enhanced mobility and communication of water operators (e.g., through pick-ups, mobile phones, computers, digital appliances) is also modifying their embodied cognition.

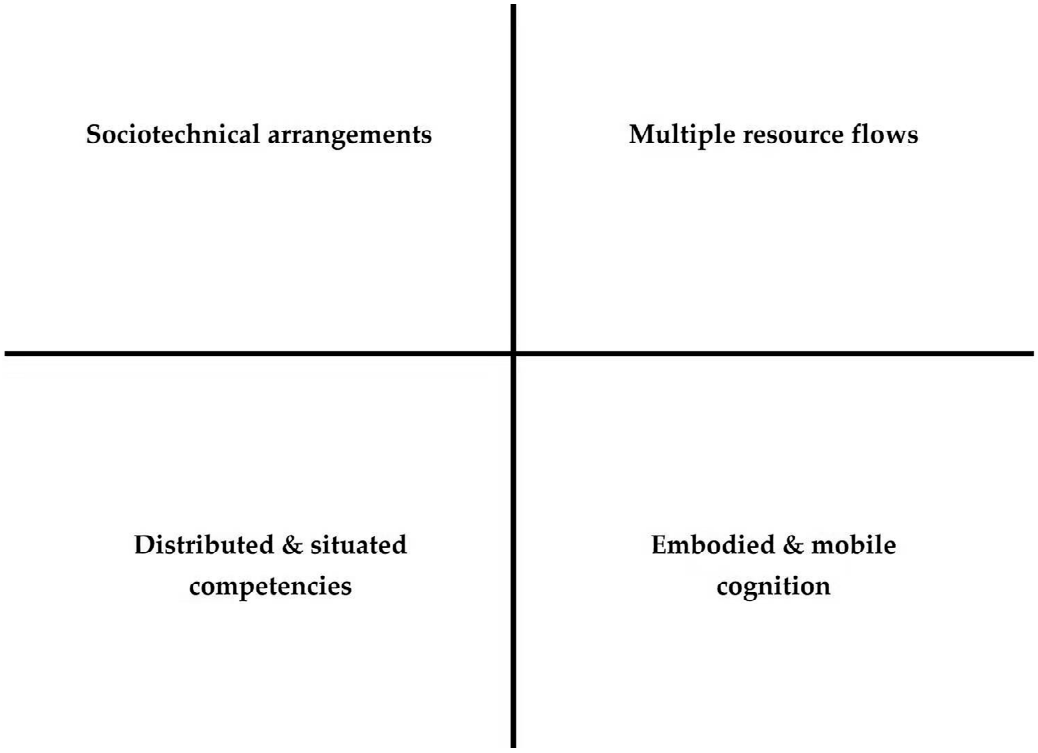

Figure 7. Framework to corroborate embodied cognition in water provision arrangements.

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