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Water Meters and Monthly Bills Meet Rural Brazilian Communities: Sociological Perspectives on Technical Objects for Water Management

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Summary. — Lasting solutions for communities in need of improved water and sanitation services—notably rural ones—depend on a balanced consideration of what some have called natural, technical, and social factors. Worldwide deficits in access to appropriate water services in rural areas highlight the need to develop sustainable management models, which are increasingly being proposed with an emphasis on local user participation. The current research analyzes a case study of two rural communities in Northeast Brazil who recently began receiving water supply services through the SISAR, a state-affiliated organization underpinned by shared management with local actors. Using sociological frameworks based conceptually in Actor-Network Theory, the study's main objectives aimed to characterize what changes—if any—the application of the SISAR's model would produce upon local dynamics, be them wide-scale or intra-household. Field research was carried out over three months in 2014, in which the researcher interviewed a handful of professionals and several dozens of local residents during an extended *in situ* research phase. Our study finds that two technical factors (the water meter and monthly bill) were at the heart of key tensions and uncertainty for users in the new water management model. Lacking appropriate guidance, users acquainted themselves with these technical objects with what personal resources, interests, and intuitions they possessed. Users were without instruction on how the meter worked, how to understand the bill, and did not know that a price table even existed. Consequently, users revealed unknown qualities of these objects that countered the service provider's intentions to rationalize water use, and adopted attitudes and behaviors marked by subjective impressions of precaution and frugality. The findings show that technical objects have no self-evident qualities to users and, thus, users must learn or be taught how to interact with them in such a way as to produce desired outcomes. Rushed attempts at establishing low-cost, so-called participative models may indeed have heavy consequences. The most significant of which is an unfavorable climate for the formation of societies where informed individuals collectively possess the tools required to grasp the situations they live within and manage sustainable water supply systems. Awareness of one's environmental impact is predicated on knowledge of one's consumption. Thus, this research contributes to development-related discussions by demonstrating that producing particular user attitudes and behaviors on a mass scale vis-à-vis resource consumption requires regular efforts to understand and mediate the encounter between users and non-human actants.

Key words — sociotechnical innovation, water management, environmental sociology, Actor-Network Theory, Latin America, Brazil

1. INTRODUCTION

Amidst concerted worldwide efforts to universalize access to water supply and basic sanitation services, [1] it is increasingly recognized that the obstacles in the way of achieving related internationally established goals are neither purely technical nor social. The pioneer efforts to provide sustainable water services to the world's citizens, such as the 1977 Mar del Plata Report, are explicit in emphasizing the need for "engineering and feasibility studies on projects … based on a cost-effective technology appropriate to local conditions, with community participation…" (United Nations, 1977). Innovation in water supply and sanitation services has been an intensely researched theme since this era. [2] In years passed, a light has long been cast on technocratic—also denominated "top-down"—solutions that, although emphasizing on technological efficiency, do not endure for lack of consideration of what some have deemed "social" aspects. [3] Thus, innovators or policymakers hoping to successfully "modernize" or "improve" a given society are increasingly aware that their "solutions" must retain a certain compatibility with otherwise organic, local modus operandi. The involvement of end users, in particular—"bottom-up" management—is often represented as a condition for success. Even major financiers like the World Bank have underscored the importance of ensuring the participation of local, non-expert stakeholders in development projects as a prerequisite for loans. [4]

More recently, researchers influenced by Actor-Network Theory (ANT) [5] and other "relational ontologies" [6] have nuanced the tripartite social-technical-natural categorization of actors involved in water management and related innovations. For these researchers, so-called "successful" cases are often indicative of harmonious reconfigurations of an "actor-network", [7] which is to say the network of all relevant human and non-human actors in a given scope. Indeed, such research has unequivocally explained the benefits of considering the interweaving associations between "technical", "natural", and "social" actors. Similarly, the present research presents a case study analysis of a participative water management model in Northeast Brazil and its aspects of enforced metering and billing of users for water consumption. Discovering serious misunderstandings between users, water meters and monthly bills that led to harmful financial consequences for users, we join other such thinkers in beckoning policymakers and development project managers to incorporate this methodological perspective in their views of and plans for development. Notably, this requires including end users and

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local experts in the design, implementation and development phases of solutions in water supply systems. Indeed, with the recent recognition of the human right to water and the United Nations' ambitious efforts to extend water and sanitation services to all people by 2030 via the Sustainable Development Goals, the time is ripe to ensure that efforts to "modernize" or otherwise improve access to water does not actually put users at further risk.

Turning to our case study, Northeast Brazil has gained international attention since the 1990s for the prominence of water management models that are supposedly anchored in participatory principles, especially in its abundant, semi-arid rural territories.[8] Yet, numerous studies[9] have concluded that the specific types of participation in practice do not always reflect entirely democratic principles and do not always produce the promised outcomes. Indeed, local residents may become discouraged instead of empowered when they are merely allowed to sit in on esoteric conversations between experts and politicians. However, the interest of the Northeast Brazilian experience goes beyond these aspects. In the past few decades, the presence of adequate water supply services has rapidly improved in rural areas, notably via local distribution networks.[10] A key characteristic of many of these services, one that is of relevance to discussions on the commoditization of water worldwide, is that they often demand user payment. Highly relevant in these developments, the example to be discussed in this article is the state-supported NGO, SISAR-CE (State of Ceará). Founded in 1996 via the state utility, CAGECE, it is Ceará's rising star and prime example of a bottom-up approach to providing low-cost water services to rural communities via local distribution networks that are mostly managed by local residents. Its particular management model is responsible for a number of significant modifications to user communities, but in this article we will focus on the actants involved (human and non-human) in user billing.

This subject is of particular relevance as the economic character of water supply services is at the heart of important discussions and controversies worldwide. The 1980s and 1990s saw the rapid expansion of neoliberalization and the privatization of water provision internationally.[11] Throughout the 1990s, the global anti-privatization movement grew worldwide, largely in protest of unmanageable price hikes imposed by private service providers.[12] In 2002, the UN Committee on Economic, Cultural and Social Rights laid the ground for the definition of the human right to water (and sanitation) via General Comment 15, and the human right to water was formally recognized by the General Assembly and Human Rights Council in 2010. Nevertheless, despite this apparent achievement, the UN organization still maintains that water services must be affordable whether provided by public or private actors.[13]

As an exclusive service provider to rural communities, the case of the SISAR is of interest to this debate. While rural areas are often neglected due to their high costs to service providers and little prospect for return, the SISAR's apparent emphasis on community involvement in systems management[14]—an aspect aligning the NGO with global trends of alternative management models[15]—appears to be a factor allowing the organization to provide services at a low cost. Given that this management model is predicated upon user payment for service (a novelty to many areas in the Ceará where water used to be supplied for free), this research was interested in analyzing the multiple changes that this model presupposed on user communities: on the one hand, from invoking community participation in management and, on the other, enforcing regular payment for water. The particular findings presented herein focus on the role of particular technical objects (the monthly bill and the water meter) as potential vehicles of rationalizing change in the SISAR's client communities. It is concerned with the ways in which users apprehended these essential objects, the relationships that were ultimately not forged between some users and these objects, and the implications of this for the SISAR's goals of rationalizing water usage and promoting local participation in water systems management.

It should not be considered unusual to direct special attention to the problematization of encounters between humans and nonhumans, as opposed to those strictly between humans. Whereas humans can more easily explain their attitudes and inclinations, it is precisely because of communicative voids between human and nonhuman entities that orchestrated encounters between the two seem susceptible to so easily going awry—that is, from the perspective of the humans behind the orchestrating. In this case, the reasons behind users' poor appropriation of water meters and the monthly bill were also indicative of the reasons why increased local user participation in systems management was not attained either.

As Law and Callon (1992) point out, successful projects and institutions tend to more easily hide processes of inefficiency and potential failure. Therefore, in presenting our findings we aim to contribute to an expanding analytical framework[16] for the description and understanding of user interaction with the necessary technical and natural entities involved in water provision. This article proceeds by describing the methodology used to obtain the findings. It then contextualizes the emergence of the SISAR in Ceará and its arrival in the communities under analysis. It follows by presenting the dynamics between users, the previously mentioned technical objects (water meter and monthly bill), and other relevant stakeholders (SISAR employees and local delegates). The discussion explores why local users did not unanimously adopt attitudes of rational consumers and engaged citizens in local water management. We conclude by exposing important sociotechnical difficulties to creating sustainable, participative water management services.

2. MATERIALS AND METHODS

The current research was developed over twenty-two weeks in mid-2014 as a part of the DESAFIO Project, whose overall objective was to research socio-technical innovations in water governance. The communities chosen were Andreza and Arataca, two neighboring rural communities managed via the SISAR for approximately one year when the research began. Given the conceptual stance adopted by the DESAFIO project, what with the binary designation of socio-technical innovations, Actor-Network Theory appeared to constitute a worthy methodological inspiration that would allow the research to tease out the meanings behind what some stakeholders might come to qualify as "social" and "technical" aspects of the SISAR's water management model. Thus, the questions that oriented this specific research study consisted in: understanding how the SISAR's particular water management model affected local life, what such changes consisted in and which actants were specifically responsible for them, who was most affected by such changes and in what ways, and if these changes were consensually considered to be positive or negative by all stakeholders involved.

Qualitative socio-ethnographical methods were applied consisting in a combination of bibliographical and documentary research, approximately 80 semi-directive interviews with a

variety of key stakeholders, and participant observation. Key stakeholders were divided into three groups: SISAR staff or other "professionals", local delegates (community members involved in water management via the SISAR), and water users.

The first group was interviewed in Fortaleza on the grounds of the regional headquarters, which are shared with the headquarters of the state water and sanitation utility, CAGECE. A total of five semi-directive interviews were conducted: three with SISAR managers, one with a CAGECE executive director of rural sanitation, and one with a local representative of the World Bank (financier of State water infrastructure programs that are subsequently managed via the SISAR). Interviews with the first group of stakeholders aimed to understand the history of the SISAR model and the process by which the organization establishes and maintains itself in communities. Furthermore, the researcher sought the interviewees' assessment of: the changes that the SISAR's management model brings upon local life in rural Ceará; the relationships maintained between these professionals and local community members; and the factors that they believed constituted a successful or non-successful intervention on behalf of the SISAR. When possible, these stakeholders were always encouraged to address the specific cases of Arataca and Andreza.

During a six-week period between June and July 2014, *in situ* research was conducted in Arataca and Andreza during which approximately 80 semi-structured mini-interviews of varying lengths (15 min to several hours) were conducted. With the concern of ensuring that locals would trustfully engage with the researcher, each community's respective local operator (role described further on) was requested to accompany the researcher in house-to-house visits for the first two to three days. After this period of time, given the concern that the operator's presence would bias the attitudes and statements of residents, the researcher spent full days traveling alone from house to house to make contact with the communities' residents and observe their day-to-day lives and living conditions.

The researcher lodged alone in one community and with the family of the local water systems operator in another. As specified, the research categorized local inhabitants into two groups: water users and local delegates, meaning the operators and members of the communities' local associations who had guaranteed ties to the SISAR organization. This classification was necessary to respect the hypothesis that the establishment of the SISAR's management of water resources would not necessarily affect local users.

The researcher regularly spent time with both communities' operators and with executive members of each community's association. Regular contact with these key informants was underscored by the mission to understand: how they became involved with the SISAR; what their participation consisted in; and their personal attitudes and behaviors regarding water consumption (e.g. in what ways did they consume water differently—or not—after the SISAR arrived?). The researcher also sought their assessment of: how the SISAR's establishment had potentially changed other local users' lives; their relationships with local users before and after the SISAR: and, the perceived successes and/or failures of the organization's projected outcomes.

Given the time allotted and the limited geographic distribution of most local users' households, the researcher was able to establish contact with a high proportion of local users from all locations in both communities.[17] The adopted approach was underscored by the principle of "saturation", which considered that the eventual repetition of similar information by various respondents could be indicative of one or more general realities, beliefs or opinions that could warrant the closure of certain interview phases. Some users were interviewed more than once if judged necessary by the researcher. The researcher sought out local users at their places of residences and in any places in which they may get together in groups, such as churches, shops or other similar venues. At the discretion of the researcher, integration in all different forms of local social life was considered an asset to the posterior interpretation of the research findings. Questions asked to locals sought to elucidate in what ways local life and their own specific lives had changed—if at all—since the establishment of the SISAR's management (e.g. quality and quantity of water consumed, time and money saved and spent on other things, uses for water and quantities used). Specifically, questions were designed to evoke users' attitudes and behaviors with regard to their water consumption both before and after the SISAR's arrival; Are you happy with the water supply that you receive at your home? What do you think of your water bill? What has changed in your life since receiving water in your household? Do you use water for things now that you did not before?

It is important to specify that when we refer to attitudes and behaviors throughout the present article, by attitudes we mean settled ways of thinking or feeling about a certain subject (e.g. a user considers water expensive), and by behaviors we mean specific ways of acting (e.g. said user, when showering, turns off the water while washing the body). Indeed, the research made it a priority to understand: why users possessed the attitudes they did with regard to their water consumption, if and why these attitudes were different before the SISAR had arrived, and their corresponding behaviors regarding water use before and after.

When speaking with the local users, the researcher adopted an attitude of ignorance regarding the functioning of the SISAR, thereby seeking to assess to what extent and how local users had assimilated the changes triggered by the organization's establishment locally (i.e., preliminary questions included "What is the SISAR?" and further on in conversation, "Does the SISAR have anything to do with your local association?"). Moreover, the researcher sought the local users' assessment of their relationships with local delegates, who were necessarily fellow local residents.

Finally, the researcher gave special importance to being present for all situations in which any SISAR employee would enter into contact with Arataca and Andreza's local users. These scenarios included maintenance calls that would require a technician to perform a repair locally, the distribution of monthly bills and/or fines, and organized annual meetings between community members and SISAR managers.

Through several detailed user accounts of local history and then-present dynamics, the research was able to compile this data into a brief ethnography that would serve to better contextualize the arrival of the SISAR in these communities. Therefore, the findings presented in this article are the fruit of weighing, on the one hand, the discourse and attitudes of human participants' regarding their interaction with water and, on the other, the dynamics of the communities' actor-networks (e.g. local history, social representations of water and water-related practices, characteristics of the monthly bill and the water meter). This juxtaposition helps to explain the mixed success of the SISAR's objective of providing sustainable water services to user-communities while bolstering local participation in water systems management.

3. RESULTS: THE SISAR—A LOW-COST, PARTICIPATIVE MANAGEMENT MODEL

The Integrated Rural Sanitation System of Ceará (SISAR/CE) is a non-profit civil association whose main financial contributor is the CAGECE. It is composed of the local rural associations that represent its user-communities and a corps of managers and technical employees in each of its regional catchment areas. Its foundation in 1996 was prompted in part by the need to ensure that rural water supply systems, which were often created with funds from international or national investment programs, would arrive at their planned service life of twenty years (Silva, 2014). Managers and representatives describe the organization's decentralized model as a low-cost solution that relies on community participation, an imposed billing system, the installation of residential water meters and the accompaniment of the communities receiving systems. Since its creation, the same management model that was initially created for rural communities in the Sobral region (Ceará) has been replicated a number of times to establish a total of eight different regional SISARs that span the entire state of Ceará, serving 1,062 communities and a total of 406,599 users across the state's 11 drainage basins. [18]

At the cornerstone of SISAR's praised management model is its emphasis on "shared management" with local communities. This translates concretely into the creation of an original chain of command. Users are encouraged to contact their "local operator" (a community member elected to take charge mainly of maintenance responsibilities) or their local association's representatives with any problems or inquiries rather than their regional SISAR office. In the SISAR's vision, local community associations [19] are considered to be local leaders. Moreover, SISAR personnel expressed that giving local association members responsibilities linked to water management was meant to empower them (Ribeiro, 2014). For instance, in each of the eight SISARs' executive administrations, the General Assemblies and Fiscal Councils are comprised entirely of presidents of the associations that enroll their services.

According to the SISAR model, users' main responsibilities consist in paying their monthly water bill, preserving their water distribution system and reinforcing their local association (CAGECE, 2015). This merits some particular remarks as concerns the principle of user participation in this management model. First and foremost, it may appear audacious to suggest that paying one's bills is an expression of user participation in the context of global struggles to universalize access to water and sanitation systems; it is nevertheless a fundamental condition for the model's sustainability. Secondly, the SISAR's stated endorsement of user participation actually translates to their participating *in their local association*, whose leaders, among their other activities, do coordinate with the SISAR. This was identified as a potentially significant factor, since unfavorable user perceptions of their local associations (e.g. disagreement or disinterest with the latter's activities or centers of interest, past, and present) could dissuade them from becoming involved in managing their local water distribution system. [20] In sum, the SISAR necessarily triggers the restructuration of already existing social and technical systems in Ceará's rural areas, hoping that local users will not only adhere as clients but will gain motivation to increasingly participate in their local associations. As other research [21] on water systems in rural Northeast Brazil has pointed out, the novelty herein is essentially the transformation (or rather transfer) of water management into a "community object".

(a) *Billing requires a deployment of new technical objects*

The SISAR's billing mechanism differs from many conventional water-billing mechanisms in Brazil and other parts of the world. For the communities that were studied, [22] Arataca and Andreza, the SISAR tariff comprised three elements that amounted to a total of BRL 12.00 (USD 4.43) in normal conditions: the operator fee of BRL 3.00 (USD 1.11), the administrative fee of BRL 1.00 (USD 0.37) (both fixed amounts destined to local stakeholders) and the minimum consumption fee of BRL 8.00 (USD 2.95) paid to the SISAR. The consumption fee is the base of a particular economic mechanism that is the conceptual center around which the research's findings gravitate. Indeed, since measurement is paramount to billing and technical objects are the most efficient tools to doing so, the water meter and the bill thus became new members of local actor-networks in the rural communities enrolling the SISAR's services.

In the SISAR model, all monthly consumptions up to 10 thousand liters are charged at the same minimum rate of BRL 8.00 (USD 2.95), and any excesses are charged according to a progressive rate (Figure 1).

For a family of three, the total of 10 thousand liters per family per month surpasses the category of "optimal access" to water defined by the World Health Organization. [23] According to a study performed for the World Bank (Spink & Teixeira, 2009), it was a strategic decision on the part of the SISAR to establish a relatively high cap within which all consumption would be billed equally. Based on the experiences of similar water management models in neighboring states, the study found that the establishment of a high limit would discourage fraudulent user behavior (e.g. tampering with water meters) and facilitate user budgeting.

SISAR employees, association members and many users revered the imposition of paid services as a key to the organization's growing success in Ceará. Indeed, throughout the 1980s and 1990s, many water distribution systems were built in rural communities throughout Ceará and Brazil and were meant to operate free of charge. As was the case in the communities under analysis, this often led to problems of excessive user consumption and water scarcity. Thus, many SISAR managers and employees identified the mere transition from free water distribution systems to billed systems as one of the most innovative characteristics that the SISAR brings to rural communities, as it has often succeeded in curbing user consumption (Pereira, 2014; Ribeiro, 2014). Accordingly, significant portions of public presentations on the SISAR model detailed the amount of funds collected from its users as well as rates of on-time collection in each of its communities. Indeed, the SISAR faced a serious problem of persisting non-payment in many user communities even after being present in some regions for several years. An executive employee posited that this was due to users' supposed "lack of culture" with respect to bill payment; the research findings provide tools to tease out this simplistic affirmation.

Recapping, although the SISAR has been represented as a successful model that kindles the greatly discussed concept of local "participation" in water systems management, bill payment proved to be an obstacle to achieving the most basic forms of user participation; in the communities examined herein, some users had been in arrears for more than six months. Of course, attributing non-payment to a "lack of culture" was a vague explanation that, nevertheless, appeared to present a lead. Simply put, certain qualities of users' attitudes and behaviors with respect to water consumption seemed to

m³	Residential	Commercial	Waste	Price m³ res.	Price m³ com.	Variation	
0 -10	8,00	10,71	4,00	8,00	10,71	1,00	1,00
11	8,80	11,78	4,40				
12	9,60	12,85	4,80				
13	10,40	13,92	5,20	0,80	1,07	1,00	1,00
14	11,20	14,99	5,60				
15	12,00	16,07	6,00				
16	13,04	17,46	6,52				
17	14,08	18,85	7,04				
18	15,12	20,24	7,56	1,04	1,39	1,30	1,30
19	16,16	21,63	8,08				
20	17,20	23,03	8,60				
21	18,60	24,90	9,30				
22	20,00	26,78	10,00				
23	21,40	28,65	10,70	1,40	1,87	1,75	1,75
24	22,80	30,52	11,40				
25	24,20	32,40	12,10				
26	25,80	34,54	12,90				
27	27,40	36,68	13,70				
28	29,00	38,82	14,50	1,60	2,14	2,00	2,00
29	30,60	40,97	15,30				
30	32,20	43,11	16,10				
31	34,00	45,52	17,00				
32	35,80	47,93	17,90				
33	37,60	50,34	18,80	1,80	2,41	2,25	2,25
34	39,40	52,75	19,70				
35	41,20	55,16	20,60				
36	43,18	57,81	21,59				
37	45,17	60,47	22,58				
38	47,15	63,12	23,58	1,98	2,66	2,48	2,48
39	49,14	65,78	24,57				
40	51,12	68,44	25,56				
41	53,30	71,36	26,65				
42	55,49	74,28	27,74				
43	57,67	77,21	28,84	2,18	2,92	2,73	2,73
44	59,86	80,13	29,93				
45	62,04	83,06	31,02				
46	64,42	86,24	32,21				
47	66,79	89,42	33,40				
48	69,17	92,60	34,58	2,38	3,18	2,97	2,97
49	71,54	95,78	35,77				
50	73,92	98,96	36,96				
51	76,50	102,42	38,25				
52	79,09	105,88	39,54				
53	81,67	109,34	40,84	2,58	3,46	3,23	3,23
54	84,26	112,80	42,13				
55	86,84	116,26	43,42				
56	89,65	120,02	44,82				
57	92,46	123,78	46,23				
58	95,26	127,53	47,63	2,81	3,76	3,51	3,51
59	98,07	131,29	49,04				
60	100,88	135,05	50,44				

Figure 1. *Excerpt of SISAR progressive price table.*

prevent them from becoming the users that the SISAR ideally wanted. To be more precise, rather than demonstrating a lack of culture regarding bill payment—virtually all users paid for residential electricity—users demonstrated inconformity, a lack of familiarity, and distrust regarding the technical objects that bridged the gap between them and the SISAR managers. As Akrich, Callon, and Latour (2006) point out, the harmonious reconfiguration of an actor-network requires some actants to traverse an "obligatory point of passage". The research demonstrated that the SISAR had not ensured that users understood how the water meter worked, the link between the water meter's information and the information on the monthly bill. Briefly said, the SISAR had neglected to take the steps required to make self-responsible users pay for water supply services. It was thus that the uninformed relationship between users and these technical objects inevitably led to uninvolved relationships vis-à-vis local systems management.

(b) *Socio-historic context of the Itapeim Complex*

The farming-based rural communities of Andreza and Arataca are located in the semi-arid region of Northeast Brazil, with 7 km distance between one another and approximately 20 km distance from Beberibe, the municipal capital. In 2014, a total of 685 residents living in 245 dwellings (2.8 inhabitants per dwelling) lived in Andreza, while a total of 471 residents living in 144 dwellings (3.3 inhabitants per dwelling) lived in Arataca.[24] Consisting essentially in residences and sparse informal shops, the communities lacked any diversity with

respect to societal structures, either institutional or commercial. Since 2008, a paved road facilitates access to the municipal capital, Beberibe, allowing residents as well as merchants to access the communities in 30 min instead of what previously required approximately 60–90 min on dirt roads.

The communities received electricity just before the turn of the century, in about 1999. For scores of local residents, having electricity in their home was their first experience as a client of an external service provider. Indeed, in response to the previously mentioned claim that Ceará's rural water users may lack a culture of bill payment, it was noted that many residents had as much as 15 years personal experience as a user of a service for which they regularly paid a bill prior to the SISAR's arrival.

Historically, water supply practices in Arataca and Andreza were generally of a precarious nature before the arrival of the SISAR; they still were for various users that were encountered throughout the research. Such practices often demanded considerable physical efforts and the necessity to seek out water from a combination of unmonitored sources: wells, the Pirangi River, or harvested rainwater.

"When I was little and was living [with my parents] there were two things about this place that made me not want to live here... I really liked living here but it was hard because I didn't like to go out into the bush and cut down...wood to make fire...And the lack of water, because it was insufferable to go and fetch water...Even if we lived close to two wells... we had to wake up early every day... and lug back a jug of water" (Resident of Arataca).

In approximately 2003, the communities of Andreza, Arataca and Itapeim (a community located between the latter two communities) were benefited with a water distribution system that was constructed with funds from Brazil's National Health Foundation (FUNASA), named the Itapeim Complex. The system, consisting in piping treated water to water towers in each of the three villages, was left unsupervised and was all but destroyed in a few years due to illicit user interventions aimed at bringing water closer to their dwellings.

During 2012–13, the FUNASA again funded the construction of a new distribution network that would install individual water connection at users' dwellings in all three communities. Users, association members and SISAR managers identified two main flaws with this new configuration, consisting in a combination of both social and natural factors. The first was a general tendency of excessive user consumption. This was widely attributed to the fact that users were allowed to take water from the distribution network free of charge. The second consisted in the Pirangi River's natural supply capacity. Together, the network's infrastructural configuration and heavy user demand combined to exhaust the river's resources. Thus, users that were closest to the distribution network's intake point were the few that regularly succeeded in making use of the system. Users at an intermediate point in the network only occasionally succeeded in receiving water, which could tend to be more turbid and generally of poorer quality, and many users never received any at all.

(i) *Rapid introduction of the SISAR into communities*

In 2013, the SISAR-BME (Fortaleza catchment area) contacted executive members of both local associations to propose their services in water management. It should be noted that in both communities the local associations in question had existed for more than ten years. Negotiations were successful with the association members and, thus, assemblies were organized in the communities to inaugurate the enrollment of the SISAR's services. When asked to comment on this process, SISAR managers who had been present at the assemblies in Arataca and Andreza explained that their objective at these assemblies was, above all, to explain the billing conditions of the new system, the new responsibilities of local actors (association and operator), and a condition that was specific to these communities: that the water transported through the distribution network would not be guaranteed as potable due to insufficient financial and technical means.[25] This information was recorded in a hand-written "act of affiliation", as per the SISAR's standard operating procedure. It was kept by the associations and was virtually never seen again by any users. No additional documentation was left with any other community members, which was one of many signs of the SISAR's very limited communications approach vis-à-vis its user communities.

When asked to comment on their access to water, the vast majority of users expressed overall increased satisfaction since the SISAR's arrival. Many outwardly made a connection between the establishment of a billed system, a subsequent reduction in overall user demand and the increased responsibility of users' water consumption. It was widely noted that water quality and availability improved, especially for users furthest from the treatment station who had never received any water at all before the SISAR's arrival. However, services were still not close to being at users' ideal levels of satisfaction; users frequently alluded to desiring more consistent service and access to potable water. Indeed, there were periodical water shortages in the network, water quality was susceptible of drastically degrading (especially during the summer months) and was never within potable standards, as mentioned previously. Users demonstrated recognition of both anthropogenic and "natural" push and pull factors that affected water procurement in their local actor-network. On the one hand, the imposition of billing had the positive effect of decreasing human demand on water. On the other, the Pirangi River's water levels traditionally decreased in summer months and consequently generated higher concentrations of foreign matter in its waters.

At the same time, the vast majority of users demonstrated various degrees of fragmented understanding with respect to the "new guy in town". The SISAR's management model, the contents of the monthly bill and the way in which the water meter functioned were all mysteries to the vast majority of users. In very initial phases, this need not seem surprising. Many researchers[26] have highlighted that the introduction and dissemination of innovations implicate complex processes that can destabilize otherwise ordinary human behaviors, especially routine behaviors. In this case, it was incumbent on the SISAR to assess the inevitable changes that would arise in its communities' actor-networks and ensure beforehand that all stakeholders involved would harmoniously assimilate them. Without adequate direction, it is unrealistic to expect individuals inhabited by long-established attitudes and behaviors to become not only intelligent users, but increasingly implicated citizens in local collective life.

(c) *Measuring water consumption acquires a new significance for all stakeholders*

Since the SISAR's arrival in the communities, the measurement of water consumed per dwelling became a much more important piece of information for all stakeholders involved. Indeed, the managers of an economically rational management model require precise knowledge of measurements in order to justly bill users. Similar to countless water distribution systems

around the world, humans require the intervention of technical objects to mediate such fine calculations. In the case of the SISAR, the water meter was the organization's actant of choice. In fact, it was seemingly the only missing piece of the puzzle for the distribution network in Arataca and Andreza, where for years there had already been an array of other technical objects including water pumps, pipes, reservoirs, and taps. Establishing the SISAR's model was thus conditional on installing meters in this network. Indeed, it is the sole actant responsible for translating the reality that had long been hidden in tubes and neglected into "objective" information available to all through its rolling numbers.

The monthly bill is the physical manifestation of the events that the water meter registers, a declaration of apparent facts and firm consequences with respect to the agreement established between the SISAR and local users. Indeed, like all waves of innovation, the SISAR combines the symbolic and the operational,[27] hoping that these two components will come together in the spread of its innovation to promote "progress" and, ultimately, shape the future of the communities accepting its services. As mentioned previously, the SISAR's employees viewed user billing as an inescapable element to the future of water management in Ceará. The water meter and the monthly bill provide information that is seen as an efficient key to remotely apprehending thousands of users' behaviors without ever having personally observed any of the users themselves.

For users, in particular, the measurement of their consumption via the water meter henceforth weighed upon on their family budget differently than it did in the past. Before the SISAR's arrival, water nevertheless constituted a good with market value in these communities. While some users would fetch limited quantities of water on foot, bicycle or their own personal animal, many would make weekly or twice weekly payments of between BRL 5.00–10.00 (USD 1.84–3.69) per trip for deliverymen to fetch water via animal-drawn carriages, delivering between 400 and 500 L water per trip. Upon the SISAR's arrival, this market that existed around water (more precisely around its delivery) was severely affected. Paying the SISAR's marginally higher price once per month could theoretically provide users with access on tap to as much as 20 times more water than what they had previously paid for.

(d) *Explaining the encounter between users and new technical objects*

However, many users challenged the *a priori* capacity of the SISAR bill's to reflect their behavior; the results obtained from the water meter could at times appear surprising, if not false to them. During the research, tension and contestation with respect to the new water distribution system gravitated around these two technical objects, revealing both their operational importance to the SISAR's innovation and their potentially problematic adoption by users.

Local users often demonstrated that they had not assimilated the SISAR's measurement and billing mechanisms in a way that SISAR managers may have ideally desired. Users generally demonstrated ignorance or misunderstanding of these elements through the expression of misinterpretations (of the billing mechanism and the bill itself), doubts (regarding the water meter's precision) and/or obliviousness (of the possibility of using the water meter to calculate their consumption). Responding to the question, "Do you have any way of knowing how much you will pay for your water at the end of this month?", most users commonly provided an answer similar to this user's, "With the way the system works... At least as far as I know, I couldn't tell you if I have already reached 10 thousand liters, if I've already passed it, how much [the bill] is going to cost, no. We always just find out once the bill arrives."

One probable explanation for this is that not a single community member knew that a price table existed. While the price table was evidently an essential document in order for any user to understand the price of his/her monthly consumption, this vital informational tool was neither attached to the monthly bill, nor sent out to users upon the community's affiliation, nor included in the community's initial act of affiliation. In fact, the SISAR's common practice does not entail users signing a contract and individually agreeing to terms of service either. Instead, a SISAR manager specified that users could obtain the price table upon request; they had historically received very little, moreover. While some users demonstrated that they desired more information—during some rare interviews, residents sought past bills and attempted to compare the information between them—they appeared to require better skills in order to precisely measure their consumption in a given month and produce a bill of a desirable cost. Surprisingly, all but one of the interviewees in Andreza and Arataca expressed interest in having access to a price table or a similar document, despite the researcher's attempts to incite local actors' interest by asking if such a document existed.

Furthermore, other users apprehended the water meter in ways expressly undesired by the SISAR, including by illicitly modifying the meter or environing actants that could have an effect on this technical object. Their ultimate objective in doing so was to take control of their new situation and avoid the payment of water. Such interventions could appear less surprising when taking into consideration the particular past of these communities; for years, scores of users illicitly modified their community's previously established water distribution network.

The SISAR, however, invested an unwavering "world of meaning" (Akrich, 1992) in the water meter and, consequently, in the monthly bill. In an annual community assembly between SISAR managers, community users and association members, one manager reaffirmed the water meter's epistemological supremacy,[28] stating to all those present, "One may think, visually speaking, that one hasn't consumed a lot of water... But what proves what has been consumed?" (Pereira, 2014). This rhetorical question surfaced in the context of a tense assembly that had clearly identified a hurdle for the SISAR. Firstly, although such assemblies with SISAR employees are usually only annual events and, thus, could be indicators of a community's involvement in water systems management, merely eight water users were in attendance. Secondly, all users present had come to express dissatisfaction and disagreement with expensive water bills that they had received at different times throughout the year; service to many of these users had been deactivated for non-payment. Tensions between the SISAR managers and the users proved to gravitate around the monthly bill and its symbolic consequences. Ultimately, the bill reigns over the user, making affirmations about the user's consumption of water and imposing costly responsibility on him/her. Consequently, disagreeing with the bill was equivalent to disagreeing with the water meter (see Figure 2). Users clearly articulated this connection by pointing out some of the meter's unjust qualities, which will now be discussed.

Figure 2. *Water meter used by SISAR.*

(i) *The meter and the man—reciprocal definitions*

The arrival of the water meter signified multiple collisions: with particular environments that possessed their own distinct, "natural" conditions; and with previously established local societies populated by humans with unique attitudes and behaviors. Throughout the research, many users stated that they had not been informed of the date or particular time at which the water meter would be installed at their dwelling; "I just came back home from work one day and it was there." A full year later, all but very few of the users interviewed stated that they made any use of the water meter whatsoever; "the operator or a guy from the SISAR comes and messes around with it". Many users stated that they had never taken the trouble of analyzing the apparatus and had not discovered any possible uses that could be made of it.

Should they have been brought to analyze it, some may have deduced from the unit of measurement "m^3" marked on the right-hand side of the rolling numbers that they could indeed measure and confirm the accuracy of their consumption. However, the ability to perform such deductions is, of course, dependent upon the capability of users to apprehend such systems and the additional information available to them. For example, the vast majority of the users interviewed knew they could consume up to "ten thousand liters of water" per month at the same flat rate of BRL 12.00; few users stated that they had the right to ten *cubic meters* ("m^3"). This detail alone, a calculation of equivalent units of measurement, could constitute an obstacle to a user understanding the water meter's data.

But let us assume that it would not, and instead continue in the analysis of available information. A water meter presents a total of six rolling dials that scroll through the numbers 0–9. On the right-hand side of the numbers, the unit "m^3" is written. The four left-most dials have a white background with black numbers. The two right-most dials have a white background with red numbers. In truth, for a user devoid of an instruction manual, there is nothing self-evident about the meaning of these colors. Furthermore, the monthly bill only added to the difficulty in understanding a dwelling's consumption, since it marked consumption as a whole number without any unit of measurement whatsoever (e.g. "Consumption = 18"). Thus, despite the importance that SISAR employees invested in modern systems to rationalize the consumption of water via otherwise common technologies, the techniques they employed made user empowerment difficult. SISAR employees failed to recognize that the available information was in fact obscure and inaccessible to users. However, a more important error of the SISAR's was that they had failed from the outset to encourage the entire user base to embrace and understand this important technical object.

Accordingly, some users continued to employ alternative measurement techniques that were the fruit of past experiences and practices. One farmer said that he knew that his well's capacity was 1,800 L; long ago he had summed the total number of 20 L jugs necessary to fill it. Faithful to this pre-established method of water usage, after the SISAR arrived he continued to fill his well with water from his household connection, drawing water from it when needed and only refilling it once it was nearly empty. The first time that he received a bill of several hundred Brazilian *reals* from the SISAR, he stated that he was cognizant of his sumptuous consumption. He paid the bill and tried to consume less. Months later, after receiving an even more expensive bill than the first, he firmly doubted the bill's accuracy. He considered the total amount of water consumed as stated on the bill and divided the amount by 1,800 (L) in order to know how many times this would mean that he had supposedly filled his well in said month. The result—nearly two full wells spent daily—far surpassed the frequency with which the user was sure to have been filling his well. "I have my proof", he said referring to his own empirical method. Consequently, only one conclusion could be made: the bill's amount was wrong and was based on error. When the user informed the SISAR's managers that he believed there had been a billing error, their response directly designated the SISAR's empirical tool *par excellence* and the actant at the center of this problem: a technician was sent to verify the user's water meter.

Such problems are not indicative of unreasonable user resistance; these reconfigured actor-networks had come to possess inherent risks for users by linking their consumption of water to financial responsibility. Inhabited by routines, attitudes and a life of experience, humans must learn or be taught how to adopt new practices and to make them coexist, if possible, with former ones.[29] These conflicts reveal the reciprocal nature of interactions between humans and technical objects, that "objects are defined by subjects and subjects by objects" (Akrich, 1992). The SISAR's personnel had indeed reified[30] the water meter by elevating it—the object—to a higher status than the user. Neglecting the users' particularities instead of intelligently negotiating their adaptation to a new local situation ultimately resulted in the voluntary and/or forced expulsion of several users in Arataca and Andreza from the water distribution network. In light of the SISAR's aspirations to promote social cohesion, it seems appropriate to consider such exclusions as reflections of the partial failure of the organization's innovation.

(ii) *Accommodating uncertainty in rational systems*

The communities' distribution network was reliant on human intervention and all its consequent whims. It consisted in timed water pumps that were activated once daily at determined morning hours; the morning was traditionally the time at which water use was highest in these communities. Accordingly, the distribution system's configuration aimed both to meet peak local demand in real time and to subsequently provide enough water for the rest of the day's needs. Thus, it was based on projected human behaviors and, consequently, required frequent supervision. Some mornings, when water use was not as heavy as usual, the water towers were susceptible to overflowing. Other days, when daytime water use was heavier than usual, a water tower could become empty before the following day. Thus, considerably large parts of the water distribution network could occasionally purge themselves of water and fill with significant amounts of air. Ideally, operators are meant to actively survey the state of the water towers and to react accordingly. However, both operators explained why this never happened. Firstly, they felt it was relatively difficult to do so, since one could only know the state of a water

tower's level by scaling it to the top and looking in from above. Secondly, they simply preferred reaction to preventive action, despite the possible cost of generating local dissatisfaction. "In any case I'll know quickly [if the tower becomes empty]", said one operator, referring to the local water tower and the local neighbors who would alert him if they did not have water.

The consequences of the operators' attitudes were indicative of the very consequential position that they possessed in their renewed local actor-network. Indeed, in these circumstances it often occurred that a user would open his/her tap and that only air would come blowing out. While this was a moderately inconvenient circumstance before the SISAR's arrival, the post-SISAR reconfiguration of the local actor-network turned this situation into a potentially costly one. Indeed, the water meter registered the passing of air as if it were water. This signified that users risked "paying for air" if they were not conscious of this problem or were not mindful to monitor the tap while it was open. While water users around the world may find it surprising that a user would not monitor an open water tap, it is crucial to remember that such attitudes are not innate but are learned. [31]

In the time pre-dating the SISAR's arrival in the local distribution network, it was common practice to leave one's tap open. Truthfully, one could make the case that users were acting in an economically rational fashion in doing so. In those times, one could wait for long hours beside an open tap without any water arriving at all. As long as water was free of charge, it appeared rational to leave an empty recipient beneath an open tap and to see to other affairs in hopes that the recipient would contain some water later on. After the SISAR's arrival, the tap acquired a new power as it was closely linked to the water meter. Henceforth, users would have to more closely monitor the tap and treat it with caution for fear that misuse would penalize them. Many users thus saw the interest in staying beside their taps when using them in order to ensure that it could be closed if ever air were to start coming out and the water meter were to register it. In communities where water availability was already very irregular, this preoccupation added to users' precarious living conditions.

While the water meter's registering air was considered a "dysfunction" by SISAR employees and users (that is, the few that were aware of this phenomenon), this is an inaccurate claim. The water meter was simply performing one of its entirely possible, yet undesired functions for human parties in these actor-networks, an important point to highlight for all engineer types. Indeed, this function was particularly alarming due to the levels of uncertainty that it generated. Faced with a situation in which users realized that the so-called "water meter" was a metaphorical "multi-meter", no one was capable of differentiating and quantifying the amount of air and water that had passed through it. One user swore that he had seen the meter "turn at 200 km/h" when only air was passing through it. A SISAR manager, armed with little more than belief, explained to users with unpaid bills of high amounts that the water meter "could not have possibly" registered the equivalent of several dozen cubic meters by mistake; surely these users had indeed consumed copious amounts of water. Ultimately, most stakeholders involved were cognizant of the fact that it was actually impossible to know exactly how much air or water passed through users' meters in a given month. Thus, some user reactions to the SISAR's defensive position included mixes of resentment and mistrust, even when offered consolatory discounts on their expensive bills. However, considered within the universe of these communities' local actor-networks, it was clear that the water meter was not the only cause of uncertainty. This technical object simply and indiscriminately conjugated a reality that was the end result of an intertwined web of unstable actants upon which several hundred paying water users happened to depend.

(iii) *Development of frugal attitudes and behaviors post-SISAR*

As outlined previously, many users were more or less certain, based on routine and notions of their use, that their bill would come at the minimum price of BRL 12.00 (USD 4.43). However, when asked, for example, if they knew the price of any monthly consumption that surpassed this limit (which happened frequently, as detailed in Table 1), the vast majority of users did not know and often stated that "you can only know once the [bill] arrives". At the same time, users generally responded affirmatively when asked if they had changed their attitudes and behaviors regarding water use after the SISAR's arrival. In light of all of the preceding observations, it became perceivable that many users had not made adjustments to their use patterns through what could be considered to be rational reactions to the SISAR's economic mechanisms. Instead, it was due to the consequences of inserting the SISAR model into these communities' non-simple actor-networks and the resulting atmosphere of uncertainty described above, a universe full of instabilities of which both humans and nonhumans were responsible.

Throughout the research, a great majority of users expressed frugal attitudes with respect to personal and domestic water use. They gave examples of corresponding behaviors such as taking short showers, using little water to wash dishes and not using water from the SISAR to water their plants. In turn, and consistently with social representations dating from before the SISAR's arrival, behaviors associated with abundant or unnecessary uses of water were generally stigmatized in these communities; "[t]here are other people that open the faucet and that let that water flowwwww ... I think that when you have everything in your house, everything should have a limit"; "They know how much they use ... they have fruit trees, cattle ... a motor that pumps water to fill their wells." In discussions with "frugal" users on the subject of neighboring users that had received expensive water bills in the preceding twelve months, their most cited examples of imprudent or wasteful behaviors evoked that watering one's plants or giving water to one's livestock with SISAR water indicated irresponsible attitudes and justified one's being heavily billed. One

Table 1. *Number (and total percentage) of accounts with monthly consumption higher than 10 m^3*

Community	Andreza	Arataca
May 2013	n/a	15 (11%)
June 2013	3 (2%)	15 (11%)
July 2013	20 (10%)	16 (12%)
August 2013	32 (15%)	36 (26%)
September 2013	27 (13%)	39 (28%)
October 2013	50 (25%)	21 (15%)
November 2013	41 (20%)	46 (33%)
December 2013	71 (34%)	53 (38%)
January 2014	52 (25%)	57 (41%)
February 2014	11 (5%)	36 (26%)
March 2014	17 (8%)	6 (4%)
April 2014	26 (12%)	40 (29%)
May 2014	46 (21%)	21 (15%)
Total average %	16%	22%

operator even affirmed that the higher amounts of such users' bills were due to their "aggressiveness with water".

Therefore, while the logic of the SISAR's management model is based on bringing objectivity and stability to water use by rationalizing the conditions of its use, many of these communities' users apprehended the model's mechanisms with reliance on subjective impressions of what could allow them to consume the water they desired without excessive penalty. Perhaps due to years of living in conditions of scarcity and unequal access to water, local water users commonly stigmatized those whose consumption surpassed 10 m^3.

In order to test this hypothesis and see just how many supposedly "irresponsible" users were in these communities, we analyzed the SISAR-BME's complete data on the first 13 months of service in these communities in order to identify how often users surpassed 10 m^3 per month. In the first 13 months (May 2013–May 2014), a yearly average of 16% and 22% of all dwellings regularly surpassed this cap every month in Andreza and Arataca, respectively (Table 1 here).

Trends appeared to correspond roughly with the seasons; dwellings less often exceeded 10 m^3 per month in the rainy season (in June 2013, 2% of dwellings in Andreza and 11% in Arataca) as compared to the dry season (41% of dwellings in Arataca in January 2014 and 34% of dwellings in Andreza in December 2013).

One may object to the suggestion that all such users were unknowingly and perhaps begrudgingly surpassing a level of monthly consumption that they might have otherwise desired. To account for this, we also analyzed the rate of unpaid bills throughout the first 13 months as a possible indicator to support the hypothesis that many of these users were indeed unwilling to pay what they perceived to be (perhaps unfairly) expensive water bills. Relatively high proportions of users in each of the studied communities had at least one unpaid bill throughout the 7-month period preceding the field research phase: in May 2014, 42 accounts (19% of total dwellings) in Andreza and 48 accounts (35% total) in Arataca had at least one unpaid bill. A variety of reasons could explain such high levels of non-payment. However, when asked to comment on the subject, users often stated that the unpaid bill had been particularly expensive and had seemed "to come out of nowhere", or that the quality of water had been so poor throughout the unpaid month that they felt it was unjust to have to pay for it.

Curiously, not a single user expressed doubts or critiques toward the fairness of a management model in which no user actively knew his/her current consumption and its corresponding price for the month in question. This is especially relevant for the specific rural setting under study, where many users had potentially increased needs for water as self-subsistence farmers. In parallel to the vast majority of users that attempted to keep their monthly consumption under 10m^3 in order to pay the lowest rate, other users desired higher volumes of water and made approximate attempts to attain a bill with a price that they would be willing to pay. For example, one user that was subject to a conflict with the SISAR over high water bills explained that, as a farmer, he was willing to pay well more than the standard monthly fee for water. Alas, he experienced great difficulty in attaining a monthly consumption that was not excessively over his budget.

Thus, the SISAR was responsible for producing "unjust inequalities" (Busca & Lewis, 2015) among its users inasmuch as many lacked the tools required to make their access to water affordable. Such outcomes are not desirable in the scope of worldwide efforts to universalize safe and fair access to water for all. More importantly, they contradict the normative content of the human right to water regarding affordability (United Nations, 2015) as defined in UN Human Rights Council Resolution A/HRC/15/9 (United Nations, 2010b). Many users were unfairly accused of "lacking culture" by the SISAR. One user quite astutely offered a more appropriate explanation; "I find that what is always difficult for everything here [in this community] is having an accompaniment... someone who will guide you, who knows how things happen". Users and local delegates required greater guidance from the SISAR before they could be left to collectively manage their common, yet newly reconfigured reality.

4. CONCLUSIONS

This article hones in on two non-human actants that are crucial connections between users, local delegates and administrators of the SISAR's water management system. Although administrators and users made frequent allusion to these technical objects while discussing conflict and confusion, a resolution to such problems seemed unobvious to all parties involved; many users had not developed familiarity and trust with these objects, and managers did not make it a point of achieving this as a prerequisite to overall success. The research findings echo Scardigli's (1992) comments on the potential impact of new technologies as agents of rationalizing societal change. According to the author, continuing waves of new technologies seem to depict a world perpetually "in formation"; their creators exalt their inventions as agents that will "*in-form*" society in accordance with its members' supposed interests, aspirations, and concepts of progress. Paradoxically, in the present case, while the SISAR's arrival in Arataca and Andreza did trigger changes and contribute to the formation of "modernized" local societies with an overall improved access to water, it remains difficult to say that its management system contributed to creating rational users and instilling the (ever-ambiguous) notions of "progress" in these communities.

Akrich's research (1992) highlights the importance of stability as concerns technical objects. New technical objects, she says, must ideally be "self-effacing"; the causal links that they establish must be naturalized in their target actor-network in order for them to ultimately constitute "successful" innovations. They must give the impression—as metered water distribution networks often do in parts of the world where they have long been the norm—that there was "never any possibility that it could have been otherwise" (Akrich, 1992, p. 222). In this sense, the post-SISAR configuration of Arataca and Andreza's communities was a mixed success; water did become available for nearly all users thanks to billing extravagant users. However, uncertainty regarding the price of water led users to develop attitudes of precaution and frugality regarding water consumption. Many users regularly surpassed the monthly 10 m^3 limit and maintained unpaid bills, leading to the voluntary or forced exclusion of several users from the water distribution network. Simultaneously, many users went on the line stating what they believed to be a just connection between expensive bills and excessive attitudes and behaviors. This should appear problematic for a management system whose goal is not to stigmatize certain uses of water but to rationalize use in general, which should signify a more transparent connection between use and cost.

The research demonstrated that the SISAR's employees did not make sufficient efforts either early on or throughout the model's establishment locally to negotiate [32] users' harmonious integration into the reconfigured water distribution system. As a result, the SISAR's apparently innovative, participatory

management model actually had difficulty in achieving the most classic definition of participation; user ignorance vis-à-vis the SISAR model's *modus operandi* was widespread and participation in the communities' local associations remained as dismal as ever.

Indeed, rushed attempts at establishing low-cost, so-called participative models may have heavy consequences. The most significant of which is an unfavorable climate for the formation of societies where informed individuals collectively possess the tools required to grasp the situations they live within and manage sustainable water supply systems. Many world regions are seeing the development of rapidly changing industries and cultural attitudes regarding resource consumption (water and, notably, fossil fuels). Awareness of one's environmental impact is predicated on knowledge of one's consumption. In this respect, this research contributes to such discussions by demonstrating that producing particular user attitudes and behaviors on a mass scale requires regular efforts to understand and mediate the encounter between users and non-human actants. In the next fifteen years of international efforts to bring universal access to water and sanitation systems to all people, it is essential that governments, NGOs, and service providers heed the already abundant warnings that technical objects are unable to transmit implicit meaning to humans and, in poorly managed cases, can represent risks to already disadvantaged users instead of advances.

In closing, it is a point of satisfaction to the authors that the SISAR announced its intention to launch an educational campaign via leaflets to teach users how to use the water meter and follow their consumption. Further efforts to educate users and enter into contact with them will be essential to achieving the SISAR's desired (and desirable) outcomes for water management in rural Brazil.

NOTES

1. Notably, via the formal recognition of the human rights to safe drinking water and sanitation by the United Nations General Assembly and Human Rights Council in July and September 2010, respectively (UN General Assembly Resolution 64/292 and UNHRC Resolution 15/9), and specific objectives within UN-coordinated programmes, such as the Millennium Development Goals (Target 7C) and the Sustainable Development Goals (Targets 6.1 and 6.2).

2. The current research was funded through the DESAFIO project (Democratisation of Water and Sanitation Governance by Means of Socio-Technical Innovation), a research project with 10 missions spread out across South America. DESAFIO received funds from the European Commission's Seventh Framework Programme for research, technological development and demonstration in conformity with accord n° 320303. The information contained in this article is based on the authors' opinions. The European Union is not responsible for any use that may be made of the information contained in this article.

3. See Eckaus (1977), Casciarri (2008) and Zelem (2010).

4. See World Bank (1996) and interview with Silva (2014) on SISAR, the subject of this article.

5. See Gooch (2006) and Roy (2015).

6. See Loftus (2006).

7. See Akrich, Callon, and Latour (2006) for fundamental readings on actor-network theory, and Roy (2015) for a detailed application of ANT to an urban waterscape. Despite ANT's having been an important theoretical inspiration of this research it should be noted that Grossetti (2007) provides a rich critique of this theory. All while appreciating ANT's contribution to improved analyses of human and nonhuman relations, he also highlights that founder Latour's objective of treating nature and society equally and on the same terms can lead to abandoning a great deal of social sciences' achievements, which deal precisely with the specificities of humans. In this case, the authors consider that the present findings could not have taken shape without a fine analysis of the associations between both humans and nonhumans, and indeed also consider such human particularities.

8. Taddei (2011).

9. Collard (2013), Taddei (2011), Freitas *et al.* (2014).

10. In 2000 in the state of Ceará, 60.80% of the total population had access to water via distribution network compared to 77.22% in 2010 (IBGE 2000 and 2010).

11. See Rogers *et al.* (2002).

12. For example, see Harris and Roa-García (2013).

13. United Nations, Human Rights Council (2015).

14. See Meleg (2012).

15. See McGranahan and Mulenga (2009).

16. See Casciarri (2008), Sultana and Loftus (2015), Hukka and Katko (2009), Mcgranahan and Mulenga (2009).

17. Users identities will be protected as per requested throughout this article.

18. See Brown, Pena, Rezende, and Heller (2015) for a more detailed account of the SISAR's emergence and its internal organization.

19. Should a local association not already exist in a community wishing to enroll the SISAR's services, the NGO will assist the community in creating one (Silva, 2014).

20. See Brown *et al.* (2015) for further discussion on the risks and dysfunctions of banking on local associations as vectors of community empowerment in these rural settings.

21. Collard (2013).

22. Usually, the SISAR bill comprises a forth element consisting in a fee for the electricity required to operate the distribution and treatment station. However, in the case of the communities in this study, an agreement was made with the municipal government so that it would take responsibility for paying this fee.

23. In accordance with the WHO's guidelines (WHO, 2011), the quantity of 10 thousand liters per month established by the SISAR is capable of supplying a dwelling of 3 inhabitants with 110 L/capita/daily, considered 'optimal access'.

24. Data collected from local health agents.

25. A Cagece evaluation determined that the particularly saline water that arrived at the communities' treatment station would need particularly costly technology in order to render it potable.

26. See Alter (2000), Callon (1986), Coutouzis and Latour (1986).

27. See Scardigli (1992).

28. See Loftus (2006) for an enlightening discussion on the 'dictatorship of the water meter'.

29. See Agarwal (1983).

30. See Loftus (2006).

31. See Zelem (2010).

32. See Callon (1986).

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