

FLUID INEQUITIES: THE DYNAMICS OF WATER RELATIONS AND WATER
INSECURITIES IN CEARÁ, NORTHEAST BRAZIL

by

CYDNEY KATE SEIGERMAN

(Under the Direction of Donald R. Nelson)

ABSTRACT

Household water security is commonly defined in terms of water access and potability. However, a focus on these physical qualities fails to consider the sociopolitical dynamics embedded in water-related inequalities. As a consequence, politics become limited to ensuring regional water supply rather than addressing the ways exclusion to water reflects social disparities. This dissertation builds on relational water-security frameworks by analyzing embodiment—that is, perceiving and being in the world through the body—across disciplines to examine the particular ways through which the lived experience of water insecurity, water stocks, and water flows emerge through hydrosocial (intertwined sociopolitical, economic, technological, and ecological) relations. The chapters examine the embodiment of hydrosocial relationships across the semi-arid region of Ceará, Northeast Brazil (NEB), where conflicts related to equitable access to quality water are a microcosm of the challenges faced in water-limited regions worldwide. First, I explore the embodiment of Northeast Brazilian culture, politics, and climate patterns in two experimental performance pieces by contemporary Cearense artists. Highlighting the performance of water's presence and absence, I demonstrate how performance is apt to holistically critique chronic water inequities that encompass the diverse meanings and values of water across NEB.

Then, I apply embodiment to hydrology through the assessment of evaporation rates from two multi-use reservoirs in Quixeramobim, Ceará. Colleagues and I developed a method to measure open water evaporation using floating minipans. Finally, I extend the concept of hydraulic citizenship—defined as the ability of residents to be recognized through legitimate water services—to examine the embodiment of particular hydrosociological relations through public cistern programs and the cisterns themselves. The hydraulic citizenship of the rural beneficiaries ebbs and flows across the program’s infrastructure lifecycle. Water-related challenges throughout Ceará will continue to evolve due to intertwining dynamics of climate change, policy priorities, water infrastructure, social inequalities, and water values. Greater attention to the recursive relationships between these dynamics and the lived experience of water insecurity of traditionally marginalized groups is essential to create more just water futures.

INDEX WORDS: Brazil, Community-Engaged Theater, Decentralized Water Management, Embodiment, Evaporation, Hydrology, Northeast Brazil, Philosophy of Technology, Rain-Harvesting Cisterns, Water, Water Infrastructure, Water Security

RESUMO

A segurança hídrica domiciliar é geralmente definida em termos de acesso e potabilidade da água. No entanto, o foco nessas qualidades físicas não leva em consideração a dinâmica sociopolítica enraizada nas desigualdades relacionadas à água. Como consequência, a política se limita a garantir o abastecimento regional de água, em vez de abordar as formas como a exclusão da água reflete as disparidades sociais. Esta tese baseia-se em estruturas relacionais de segurança hídrica ao analisar a corporeidade—ou seja, perceber e estar no mundo por meio do corpo—desde diferentes perspectivas disciplinares para examinar as formas específicas pelas quais a experiência vivida de insegurança hídrica, estoques de água e fluxos de água emergem por meio de relações hidrossociais (sociopolíticas, econômicas, tecnológicas e ecológicas entrelaçadas). Os capítulos examinam a corporeidade das relações hidrossociais na região semiárida do Ceará, Nordeste do Brasil (NEB), onde os conflitos relacionados ao acesso equitativo à água de qualidade são um microcosmo dos desafios enfrentados em regiões com recursos hídricos limitados em todo o mundo. Primeiro, exploro a corporeidade da cultura, da política e dos padrões climáticos do Nordeste em duas performances experimentais de artistas cearenses contemporâneos. Destacando a performance da presença e ausência da água, demonstro como o desempenho é capaz de criticar holisticamente as desigualdades hídricas crônicas que abrangem os diversos significados e valores da água em todo o NEB. Em seguida, aplico a corporeidade à hidrologia através da avaliação das taxas de evaporação de dois reservatórios multiuso em Quixeramobim, Ceará. Colegas e eu desenvolvemos um método para medir a evaporação em águas abertas usando mini-tanques flutuantes. Finalmente, alargo o conceito de cidadania hidráulica – definida como a capacidade

dos residentes serem reconhecidos através de serviços de água legítimos – para examinar a corporeidade de relações hidrossociológicas específicas através de programas de cisternas públicas e das próprias cisternas. A cidadania hidráulica dos beneficiários rurais vai e vem ao longo do ciclo de vida da infraestrutura do programa. Os desafios relacionados à água em todo o Ceará continuarão a evoluir devido à dinâmica interligada das mudanças climáticas, prioridades políticas, infraestrutura hídrica, desigualdades sociais e valores da água. Uma maior atenção às relações recursivas entre estas dinâmicas e a experiência vivida de insegurança hídrica por grupos tradicionalmente marginalizados é essencial para criar futuros hídricos mais justos.

PALAVRAS DE ÍNDICE: Água, Brasil, Cisternas, Corporeidade, Evaporação, Filosofia da Tecnologia, Gestão Descentralizada da Água, Hidrologia, Infraestrutura Hídrica, Nordeste do Brasil, Segurança Hídrica, Teatro Comunitário

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by

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DOCTOR OF PHILOSOPHY

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DEDICATION

For my grandparents, Vicki z"l and Harry z"l Seigerman.

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LIST OF ACRONYMS AND ABBREVIATIONS

ANOVA	Analysis of variance
APT	Water for All Program
ASA	Dialogue in the Brazilian Semi-Arid Region
AT	Appropriate Technology
BRB	Banabuiú River Basin
BREB	Bowen Ratio-Energy Balance
CAGECE	Water and Sewage Company of Ceará
CIRAD	French Agricultural Research Center for International Development
CNPJ	National Register of Legal Entities
CODEVASF	Development of the São Francisco Valleys and of Parnaíba Company
COGERH	Water Resources Management Company of Ceará
CONERH	Water Resources Council of Ceará
DHCP	Dom Helder Câmara Project
DNOCS	National Department of Works Against Drought
ENSO	El Niño-Southern Oscillation
FUNCEME	Research Institute for Meteorology and Water Resources – Ceará State
GDP	Gross domestic product
HFIAS	Household Food Insecurity Access Scale
HWISE	Household Water Insecurity Experience
IAC	Antônio Conselheiro Institute

IARTE.....	Institute of Art, Culture, Leisure, and Education
IBGE	Brazilian Institute for Geography and Statistics
ICC	Integrative Conservation Conference
ICON.....	Integrative Conservation
IFCE	Federal Institute of Ceará
IFOCS	Federal Inspectorate of Works Against Drought
INCRA	National Institute for Colonization and Agricultural Reform
INMET	National Institute for Meteorology
ITCZ.....	Intertropical Convergence Zone
IWRM	Integrated Water Resources Management
MC	Ministry of Citizenship
MDS.....	Ministry of Social Development and the Fight Against Hunger
MDA	Ministry of Agricultural Development
MI.....	Ministry of National Integration
MJO.....	Madden–Julian Oscillation
MST	Landless Workers’ Movement
NEB.....	Northeast Brazil
P1+2	One Earth and Two Waters Program
P1MC	One Million Cisterns Program
PhilTech	Philosophy of technology
SAAE	Municipal Water Authority
SIC	Symposium for Integrative Conservation
SISAR	Integrated Rural Sanitation System

SRH..... Secretariat of Water Resources of Ceará
SST..... Sea surface temperature
SUDENE..... Superintendency of Development of the Northeast
TEP Student Theatre of Pernambuco
TPN..... Popular Theatre of the Northeast
UGM..... Microregional Management Unit
VPD..... Vapor pressure deficit

LISTA DE ACRÔNIMOS E ABREVIATURAS

ANOVA	Análise de variância
APT.....	Programa Água para Todos
ASA.....	Articulação no Semiárido Brasileiro
AT	Tecnologia apropriada
BRB.....	Bacia do Banabuiú
BREB	Relação Bowen-Balanco Energético
CAGECE.....	Companhia de Água e Esgoto do Ceará
CIRAD	Organização francesa de pesquisa agrícola e de cooperação internacional para o desenvolvimento sustentável das regiões tropicais e mediterrânicas
CNPJ.....	Cadastro Nacional de Pessoas Jurídicas
CODEVASF	Companhia de Desenvolvimento dos Vales do São Francisco e do Parnaíba
COGERH	Companhia de Gestão dos Recursos Hídricos
CONERH	Conselho de Recursos Hídricos do Ceará
DHCP	Projeto Dom Helder Câmara
DNOCS.....	Departamento Nacional de Obras Contra Seca
ENSO	El Niño-Oscilação do Sul
FUNCEME	Fundação Cearense de Meteorologia e Recursos Hídricos
GDP.....	Produto interno bruto
HFIAS	Escala de Acesso à Insegurança Alimentar Doméstica
HWISE.....	Experiência da insegurança hídrica domiciliar
IAC.....	Instituto de Antônio Conselheiro

IARTE.....	Instituto de Arte, Cultura, Lazer e Educação
IBGE	Instituto Brasileiro de Geografia e Estatística
ICC.....	Congresso da Conservação Integrativa
ICON.....	Conservação Integrativa
IFCE	Instituto Federal do Ceará
IFOCS	Inspetoria Federal de Obras Contra as Secas
INCRA	Instituto Nacional de Colonização e Reforma Agrária
INMET	Instituto Nacional de Meteorologia
ITCZ.....	Zona de convergência intertropical
IWRM	Gerenciamento integrado de recursos hídricos
MC	Ministério da Cidadania
MDS.....	Ministério do Desenvolvimento e Assistência Social, Familiar e Combate à Fome
MDA	Ministério do Desenvolvimento Agrário
MI.....	Ministério da Integração e do Desenvolvimento Regional
MJO.....	Oscilação de Madden e Julian
MST	Movimento dos Trabalhadores Rurais Sem Terra
NEB.....	Nordeste do Brasil
P1+2	Programa Uma Terra e Duas Águas
P1MC	Programa Um Milhão de Cisternas
PhilTech	Filosofia da tecnologia
SAAE	Serviço Autônomo de Água e Esgoto
SIC	Simpósio de Conservação Integrativa
SISAR	Sistema Integrado de Saneamento Rural

SRH.....Secretaria de Recursos Hídricos do Ceará
SST..... Temperatura da superfície do mar
SUDENE..... Superintendência do Desenvolvimento do Nordeste
TEP Teatro do Estudante de Pernambuco
TPN..... Teatro Popular do Nordeste
UGM..... Unidade Gestora Microrregional
VPD.....Déficit de pressão de vapor

CHAPTER 1

INTRODUCTION

1.1 The Performance of Cearense Water Relations

“Fortaleza, the capital of Ceará, must have water, after all”—a slight, deceitful grin escapes my lips as I utter the phrase, which will be repeated several times during this performance (my third) of my body-movement-phrase composition that narrates the knowledge politics of bulk-water allocation in Ceará, Northeast Brazil, through embodied practice and prose.¹ It is February 1, 2019, and the Castanhão Reservoir—the largest multi-use reservoir in Latin America, which was built, in large part, to guarantee water supply to Fortaleza—is at 3.74 percent capacity (Hydrological Portal of Ceará, February 1, 2019). I am presenting/performing in Athens, Georgia, USA, at the annual Symposium for Integrative Conservation (SIC), organized by the students of the Integrative Conservation (ICON) PhD Program at the University of Georgia. About 6,000 kilometers away, the rainy season has officially commenced in Ceará.

Tension contracts my throat as I conclude the performance by recounting the Water Resources Council of Ceará (CONERH)’s decision to ultimately veto the bulk-water allocation decision made collectively in July by the five river-basin committees that deliberate water flows from the Castanhão to the Jaguaribe Valley and Fortaleza. While I had performed the piece twice before, this conclusion is new, unrehearsed, and raw. In the days leading up to SIC, Dr. Eduardo Sávio Martins, the president of the Research Institute for Meteorology and Water Resources –

¹ <https://www.youtube.com/watch?v=mMvr52dXrN8&t=10s>; My critical engagement with performance as method and praxis builds on the approaches and perspectives within performance studies, including Conquergood (2002), Conquergood and Johnson (2013), Johnson (2003, 2008), Kondo (2018), and Madison (2010).

Ceará State (FUNCEME) and one of my mentors in Ceará, had confirmed CONERH's decision with me. The decision had yet to be determined the first time I performed the piece, during the Integrative Conservation Conference (ICC) in September 2018 in Athens, GA, to an audience that included Eduardo Sávio and Sarra Kchouk, a Tunisian colleague from FUNCEME who helped me navigate my stay in Fortaleza during my first fieldwork experience in Ceará from May to July 2018. During this first performance, the Castanhão was at 6.29 percent capacity, equivalent to 421.21 hm³ of water.²

Between September 2018 and April 2019, I performed “The Dynamics of Scientific Knowledge in Ceará, Brazil” four times. I developed the performance by modifying a method of creating body-movement phrases, which I had learned while studying acting under Carmen Lopez y Mendoza at La Lavandería Theatre School in Madrid, Spain. First, I created discrete body-movement phrases to represent the relationships I had formed during my fieldwork—from relationships with technical experts at the Water Resources Management Company of Ceará (COGERH) and the National Department of Works Against Drought (DNOCS), to those with river-basin committee members, local professors, and employees of non-government organizations. These phrases were complemented by additional phrases that embodied the socio-ecological-technical landscapes I encountered. The delicate wilting of the parched *sertão*, or hinterlands, commences the performance to represent yearly transitions from the rainy to the dry season and the impacts of prolonged drought from 2012 to 2018 that greeted me during my first visit to Ceará. The mechanical movements I devised to embody water being released from the Castanhão contrast the landscape's gracefulness, punctuating the process of deliberating water-

² While the 2018 rainy season (February – May) was the first rainy season since 2011 with a positive deviation from the long-term mean (calculated for 1991 – 2020), drought would continue in Ceará in some regions until March 2023 (Monitor de Secas, 2023).

release scenarios. To create the final piece, I wove together these and other discrete phrases into a coherent sentence and overlaid it with prose to tell an embodied story of the power-laden decision-making processes that characterize participatory water management in Ceará.

I adapted the performance's narrative not only to the new knowledge of CONERH's decision but also to the dynamics of the Castanhão Reservoir. The night before each performance, I would check the Hydrological Portal of Ceará, available through FUNCEME's website, to update the reservoir level of the Castanhão in my prose. The first two performances told the unresolved story of the 2018 bulk water allocation decision-making process, while the two latter performances included a definitive ending to how water would be distributed between Fortaleza and the Jaguaribe Valley for human consumption and irrigation.

Although the prose and body movement phrases remained relatively consistent across performances, each experience encompassed new moments of knowledge creation that traversed traditional disciplinary divides. As a performer and scholar, I generated new embodied knowledge through my body's visceral reactions to the prose and movements I performed (Daniel, 2005). The tension that built in my throat while recounting CONERH's decision, for example, revealed to me the anger and sense of injustice I felt in reaction to the outcome. At the same time, each performance was an opportunity for collective knowledge creation with the audience (Bekker & Clark, 2018), an audience whose composition varied but typically included a mix of social scientists, ecologists, and engineers. I was reminded of the impact of these cross-disciplinary performer-audience interactions in January 2024 when I received a WhatsApp message from Sarra, an environmental engineer in the midst of writing her dissertation on drought indicators in Ceará. Five and a half years after watching my performance-presentation, Sarra reached out to cite my performance of the phrase, "Fortaleza must have water after all," in her analysis of the water

management dynamics across the Jaguaribe Valley and metropolitan area of Fortaleza. Cited in Sarra’s dissertation in a technical field, my performance, and the story it tells, “cuts across” (Certeu, 1984, p. 129) disciplinary divides to expand understandings of what knowledge is legitimate and citable in an academic context.

As I created and performed “The Dynamics of Scientific Knowledge in Ceará, Brazil,” I grappled with the ethical dimensions of my embodied performance of the water conflicts and stories of others. I am a white (Jewish) researcher from an affluent suburban area of the United States and the Global North carrying out placed-based research in an impoverished rural area of the Global South. These aspects of my positionality, as well as my affiliation with FUNCEME, afforded me access to privileged spaces and high-level authorities, such as the control room of the Castanhão Reservoir and the president of COGERH, places and people to whom most river-basin committee members and other rural dwellers did and do not have access. I recognized my position of ~~privilege~~ power as an outsider who was shown respect by many people simply because of my identity as US-ian and white.³ I questioned if I had the “right” to embody a conflict whose protagonists were, in large part, lower-class, *pardo*⁴ rural dwellers. During the development of the piece, I partially addressed this ethical question by striving to represent the multitude of stories that I had observed, all of which contributed to the decision-making process to determine the distribution of water across different regions and uses.

Since these performances, my vocabulary to describe my role and presence as a researcher and performance artist has evolved, in large part due to insights from critical performance studies.

³ I cross out “privilege” and replace the term with “power,” rather than simply stating power to highlight how, in my writing process, I initially wrote “privilege,” (unintentionally) minimizing the power relations that I benefit from as a white researcher from the Global North.

⁴ Pardo is an official racial category in Brazil, defined by the Brazilian National Supplemental Health Agency as “someone who declares themselves as *pardo* and who possesses *miscigenação* (racial mixing) with predominately Black traits” (ANS, 2023, 11).

I now understand that I acting as a “coperformative witness” (Conquergood, 2002) to local water dynamics in summer 2018 through my engagement with local people and water politics.⁵ I interviewed river basin committee members and technical experts at the government agencies, learned the technical aspects of the reservoirs in the Jaguaribe-Metropolitan-Fortaleza system from a COGERH technician, participated in water allocation meetings, toured the Castanhão with the supervisor from DNOCS, and visited the shores and drying riverbed of the Jaguaribe River with a cowboy who was also a member of the Baixo Jaguaribe River Basin Committee, among other experiences. I now recognize that the act of fieldwork is conducted with researcher and native as “co-actors, mutually engaged collaborators in a fragile friction” (Conquergood, 2013, p. 21), and my performance presentation conveyed the partial, situated truths I had, in part, helped create (Haraway, 1988).

Over the course of my PhD work, I have also developed a more nuanced understanding of the term “equity,” which has a prominent position in the title of this dissertation. Social equity refers to work toward social justice, understood as parity in social life (Fraser, 2000; Seigerman et al., 2022). It is the process of guaranteeing that people have fair opportunities to participate in social life through interconnected dimensions of recognition, procedure, and distribution (Fraser, 1995; Keeler et al., 2020; Meerow et al., 2019; Schlosberg, 2007). The recognition of social difference (recognitional equity), procedures that involve fair and participatory decision-making processes (procedural equity), and the fair distribution of risks and benefits (distributional equity) are interrelated. Yet work toward one dimension of equity does not guarantee equity across

⁵ Moving beyond the method of “participant observation,” Conquergood developed a praxis of coperformative witnessing, recognizing “what it means to be radically engaged and committed, body-to-body, in the field” (Madison, 2007, p. 826).

another. In the conclusion of this dissertation, I discuss different inequities related to water security in Ceará and the work I carried out to increase water equity throughout my research.

While my long-term dissertation fieldwork led me away from the Jaguaribe Valley and toward Quixeramobim, *o coração do Ceará* (the heart of Ceará), in the region of Sertão Central, my research questions were greatly shaped by my 2018 fieldwork on participatory water management decisions related to the Castanhão, the rural areas of the Jaguaribe Valley, and Fortaleza. The tensions of injustice that surged as I performed CONERH's decision substantiated my desire to interrogate inequities related to access to quality water in Ceará through engaged work with rural communities. The ethical responsibilities of performing the words and experiences of others that permeate the piece also flow through the other dimensions of my research, including my long-term fieldwork research, the act of publishing, and my engagement with rural communities that have become home. My research integrates across the social and natural sciences, philosophy of technology, and performance studies to explore the question, "How are interrelated sociopolitical, hydrological, and technological relations negotiated to shape water stocks, water flows, and the lived experience of water insecurity?"⁶

This dissertation focuses on the particular ways through which the lived experience of water insecurity, water stocks, and water flows emerge and are performed through ongoing hydrosocial relations, that is, intertwined social, political, economic, technological, and ecological relations (Swyngedouw, 1999). I argue that the complexity of water insecurity at the household level necessitates new ways of analyzing water insecurity across scales and that embodiment across disciplines effectively approaches this complexity. My research builds on recently

⁶ Examples of water stocks include the water stored in large-scale reservoirs, aquifers, or in household cisterns, while water flows refer to the movement of water in various forms, such as through rivers, pipelines, or into the vapor state through evaporation.

developed relational frameworks of water security, which are based on the understanding of society and nature as fundamentally interdependent (Castree, 2001; Jepson, Budd, et al., 2017). I use the concept of embodiment to integrate four seemingly disparate ways of knowing: cultural anthropology, hydrology, artistic performance, and philosophy of technology.

Embodiment refers to the bodily experience, that is, perceiving and being in the world through the body (Merleau-Ponty, 2012 [1945]). It provides a way to examine both the lived experience and larger hydrosocial relations that make up water insecurity. Observable characteristics of water—including the flow of water through rivers, the evaporation rate from reservoirs, and the water levels of rain-harvesting cisterns—can be understood as the performance of particular embodiments of place-based socionatural relationships. Although the chapters of this dissertation were written as discrete units, each one engages with the embodiment of hydrosocial relationships through which household water (in)securities materialize across the semi-arid region of Ceará, Northeast Brazil.

1.2 Water Insecurity

Water security has emerged as an important paradigm in policy and scholarship (Cook & Bakker, 2012). In Ceará, water security (*segurança hídrica*) is at the core of political discourse and policies. The *Water Resources Diagnostic of Ceará 2050*, Ceará's collaborative long-term planning platform, notes, "The guarantee of water in adequate quantity and quality for human, economic and ecosystem uses—and the prevention and response to extreme hydrological events - droughts and floods—are basic conditions for the development of society, and the same dimensions are also intrinsic to water security" (Souza Filho, 2018, p. 2). However, conventional approaches to guarantee water security, such as those delineated in the Diagnostic, normally have

a regional focus and are insufficient to understand the complex dynamics of water security at the household level, where water insecurity becomes part of the lived experience (Jepson, Wutich, et al. 2017).

At the same time, a household-level focus does not guarantee holistic approaches to understanding and improving water security. For example, in anthropology and related social sciences, water security is often analyzed from a human-needs perspective and defined in terms of having enough water of high enough quality to lead a good life (Jepson, 2014). From this perspective, water insecurity is understood as a state of being (i.e., a household is or is not water secure). Household water insecurity is evaluated along two main dimensions, potability and access, and is usually measured in terms of distance to improved water sources, such as in-house pipes or public taps and protected wells (Antunes & Martins, 2020; Zeitoun et al., 2016). Although scholars have identified water access, quality, and affect (i.e., subjective, cultural, and emotional experiences of water) as fundamental dimensions of water security (Jepson, 2014), water insecurity continues to be assessed exclusively in terms of access to water of sufficient quantity and quality (Zeitoun et al., 2016). This narrow focus on quantified water measures results in policies that homogenize the experience of water insecurity, do not consider non-material affective-emotion or sociopolitical dimensions of water insecurity, and continue to emphasize ensuring regional water supplies (Jepson, Budds, et al., 2017).

Recognizing the multiple dimensions of household water security, critical social scientists emphasize the need to consider water insecurity from a relational perspective. A relational approach refers to understanding that water security encompasses a broad range of power-laden, intersecting social relations associated with constructions such as gender, class, and race. Relational approaches create space to seriously consider the social and political power dynamics

embedded in water-related inequalities that are experienced at the household and intrahousehold levels (Jepson, Budds, et al., 2017). Relational understandings of water insecurity are posited as effective to address the sociocultural dynamics, entitlements and human capabilities, and political structures that generate the water-related inequalities that contribute to water insecurity (Wutich et al., 2017).

While the use of relational frameworks has expanded knowledge of the multiple social, political, and cultural dimensions of water insecurity, limited attention has been paid to the dynamics of concurrent hydrological and technological processes in household-water security studies (Jepson, Budds, et al., 2017). To respond to this gap, this dissertation offers an integrated framework that incorporates hydrological and post-phenomenological technological perspectives into the critical analysis of the how the embodied experience of household water insecurity is shaped and recursively helps to shape the physical environment, cultural practices and values, sociopolitical relations, and technology (Figure 1.1).

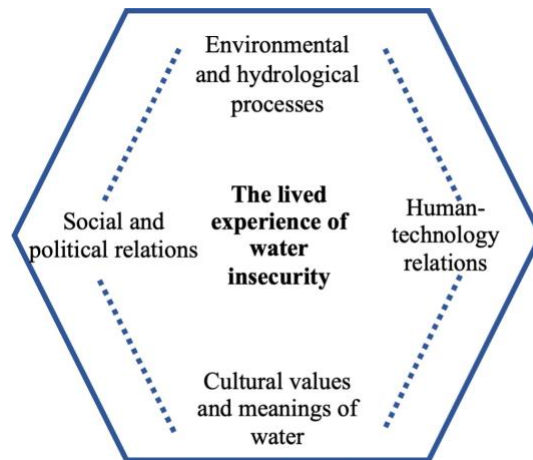


Figure 1.1 The recursive relations through which the lived experience of water insecurity emerges.

The framework builds on concepts such as the hydrosocial territory (Boelens et al., 2016) by situating the lived experience of water insecurity within the interactions among people, water flows, hydraulic technology, biophysical elements, sociocultural and political structures, and institutions. It highlights four types of relations that recursively interact with each other and with the lived experience of water insecurity: social and political relations; cultural values and meanings of water; human-technology relations; and environmental and hydrological processes. The lived experience of water insecurity does not occur in a vacuum but rather is embedded in different sociopolitical relations; cultural values; technological relations; and environmental processes. These processes give shape to the experience of water insecurity, while the everyday negotiation of water insecurity also recursively shapes these processes.

1.2.1 The Lived Experience of Water Insecurity

The lived experience of water insecurity encompasses a multiplicity of embodied experiences that reflect how people value and relate to water. Water access, water quality, and water affect (i.e., subjective, cultural, and emotional experiences of water) are fundamental dimensions of water security (Jepson, 2014). Insufficient water quality and quantity have known negative impacts on physical health (Gleick, 1996), and different dimensions of water insecurity have been linked to culturally contextualized emotional and psychological distress (Aihara & Shrestha 2015; Aihara et al., 2015; Jepson, 2014; Stevenson, 2012; Wutich & Ragsdale, 2008). Physical and emotional suffering are situated within systemic forms of marginalization through which water insecurity emerges (Ennis-McMillan, 2001; Molden et al., 2020; Sultana, 2011; Truelove, 2011).

Across cultures, there are patterns of adaptive strategies and coping mechanisms to minimize the adverse effects of limited water supply, including water sharing (Wutich & Beresford, 2019) and migration (Wutich & Brewis, 2014). Yet the effectiveness of different adaptation strategies to increase water security depends on the intersectional identities (Crenshaw, 1987) of those carrying out the strategies, as well as the socioecological contexts of the actions. In order to develop a relational understanding of household water insecurity in Ceará, in the following sections, I describe particular ways that the lived experience of water insecurity is related to the four types of relationships of the framework presented in Figure 1.1: social and political relations (1.2.2); cultural values and meanings of water (1.2.3); human-technology relations (1.2.4); and environmental and hydrological processes (1.2.5).

1.2.2 Social and Political Relations

Social relations include relationships at the inter- and intra-household level that may be impacted by social differences (Wutich & Ragsdale, 2008). For example, experiences of water sharing practices among family, neighbors, and friends are often determined by livelihood contexts, wealth, gender, and race (Wutich et al., 2018). In contemporary agricultural communities, including where I lived and worked in Quixeramobim, water sharing is largely a coping mechanism for shortage of potable water (Stevenson et al., 2012). Across the communities I visited, families with household rain-harvesting cisterns would share water with neighbors and family in different communities who did not have their own cistern or whose cistern was broken. While few people I met expressed shame in receiving water from others, globally, the practice is consistently associated with greater probability of self-reported shame and water conflicts (Wutich et al., 2022). Within and beyond water sharing, the lived experience of water insecurity is impacted

by intersectional experiences of marginalization (Deitz & Meehan, 2019; Molden, 2020; Wutich & Ragsdale, 2008).

Household water security also interacts with sociopolitical structures through the implementation of policies, participation in public programs, and interactions with officials across local, state, and federal levels. In Northeast Brazil, past and present patronage is tied to inequitable vulnerability to drought and to water insecurity experienced by small farmers (Kenny, 2002; Lemos & de Oliveira, 2004; Nelson & Finan, 2009). Initially, clientelist relations were defined by the dependence of the rural poor on wealthy land-owning elite (*coroneis*) for basic goods, including water. New modes of patron-client relations in government relief programs, through which political parties, rather than individual patrons, benefit, have largely replaced more traditional clientelist practices. In Ceará, the strongly centralized government has supported these new forms of clientelism that rely on institutional-led mechanisms to benefit political parties and that diminish the agency of subsistence farmers, ultimately leading to the persistent vulnerability of rural families (Bedran-Martins & Lemos, 2017; Lemenhe, 1995; Nelson & Finan, 2009). About 17 percent of the population is below the poverty line, with 10 percent considered living in extreme poverty. Poverty declined significantly between 1998 and 2012, following the realization of anti-poverty initiatives by the federal government (e.g., Bolsa Familia). Yet vulnerability to climate change did not decrease, in part due to the lack of investment in risk management strategies at the household level (Nelson et al., 2016). In Chapter 4, I explore how federal cistern programs impact contemporary hydraulic citizenship in diffuse rural communities in Northeast Brazil, where hydraulic citizenship is defined as the ability of residents to be recognized through legitimate water services (Anand, 2017).

Present-day water relations in Ceará are also greatly influenced by contemporary water management reform in Brazil, which began in the late 1980s. In 1988, the ratification of the Brazilian Constitution marked the reestablishment of democracy in Brazil and a shift toward greater regional autonomy, in part through decentralized water governance (Abers & Keck, 2006). Waters—including rivers, lakes, and aquifers—completely within a state became under the jurisdiction of that state, while those that traversed state lines would be under federal command (Abers & Keck, 2006). In Ceará, river basin committees were established in 1992. The National Water Law ratified in 1997 (Federal Law No. 9.433, January 8, 1997), which extended this model across all Brazilian states, included a broad integrated water resources management (IWRM) reform (Abers & Keck, 2006).⁷ Governing power was decentralized from federal and state agencies to new regional bodies defined by river basins, which encompass multiple municipalities—a traditional administrative boundary and the sub-state level—and often in imperfect overlap, such that some municipalities fall under the jurisdiction of two river basin committees, as is the case for the municipality of Jaguaratama, Ceará, which is part of the Banabuiú and Médio Jaguaribe River Basin Committees.

A fundamental aspect of IWRM is that integrated, participatory management occurs at the “lowest appropriate level,” where the river basin is the smallest management unit (International Conference on Water & Environment, 1992 cited in Abers, 2007). In part due to the ambiguity of the federal water management reform mandate, the evolution of water governance structures based on IWRM principles has varied substantially across Brazil (Abers & Keck, 2006). In Ceará, river

⁷ Article one of Law No. 9.433 (January 8, 1997) establishes water as a public good and a limited natural resource with economic value. It also states that in situations of water scarcity, human and animal consumption take priority over other uses. The Law establishes the river basin as the territorial unit for the implementation of the National Water Resources Policy and mandates that water management must be decentralized and have participation from public offices, private users, and local communities.

basin committees carry out water management decisions at the river-basin level, while decisions involving inter-basin transfers, such the transfer of water from the Jaguaribe Valley to the metropolitan area of Fortaleza, are overseen by CONERH. River basin committees represent agricultural and industrial water users, as well as civil society and municipal and state government bodies. Decisions are informed by technical information, such as risk assessments and scenarios, provided by the COGERH, which also acts as the committees' executive secretary (Lemos et al., 2020). The inclusion of civil society in the management of water resources was based on the belief that better decisions are made when a range of users are involved (Genskow & Born, 2004). State and federal agencies, including COGERH and DNOCS, respectively, also play important regulatory roles, including the management of reservoirs, monitoring of regional water-use, and maintenance of the water infrastructure for water transfers. My performance presentation explored the dynamics of the participatory water management system in Ceará and how conflicts in the interests between the State and river basin committee members impact where water flows across river basin boundaries and from rural to urban areas. About 44 percent of the Ceará's population resides in the metropolitan region of Fortaleza and accounts for about half of Ceará's gross domestic product (GDP) (IBGE, 2022). As such, supplying water to Fortaleza remains a priority of the State. The flow of water from reservoirs through canal systems, perennialized rivers, and pipelines embodies political relations that impact and are impacted by diverse water users, including households in rural and urban areas.

1.2.3 Cultural Values and Meanings of Water

Attention to the multitude of cultural meanings and values imparted on water permits more holistic understandings of differentiated experiences of household water insecurity. Analyses

move away from a monolithic understanding of “water as a resource” to recognize diverse worldviews that produce a multiplicity of material and non-material (e.g., cultural, spiritual, and emotional-affective) meanings of water (Eichelberger, 2018; Molden et al., 2018). Greater comprehension of water’s essentiality—which includes both water’s materiality and its fundamental meanings of spirit, life, wealth, and social connectivity—is possible (Strang, 2004). From this perspective, household water insecurity can be understood beyond potability and access to include affective and spiritual dimensions.

In Ceará, water is intimately related to spiritual and religious belief systems. Water’s spirituality is manifest in its role in Catholic baptisms, the veneration of *a Santa das Águas* (the Saintress of Water) or Oxúm,⁸ and the use of *o Dia de São José* (Saint Joseph’s Day, March 19) as the marker to determine whether the rainy season will arrive or not. During visits to a family in the interior of Piquet Carneiro, I would observe my friend’s mother place bottles of water on the counter to be blessed during the Catholic Mass broadcasts on the family’s TV. In the interior of Ceará, *profetas da chuva* also make predictions about the rainy season drawing on place-based knowledge and rituals passed down intergenerationally (Taddei, 2017). While the rites carried out by the *profetas* are not based on particular religious teachings, the traditions contribute to the mystic spiritualism and Catholicism endemic across the sertão.

The syncretic religious and spiritual belief systems of many people in Northeast Brazil carry traces of African, Indigenous, and Portuguese traditions.⁹ The *preceitos* (precepts) of Padre

⁸ Oxúm is the goddess of fresh water in Afro-Brazilian religions including Umbanda and Candomblé. Across Brazil, Oxúm and Iemenjá, the mother of the orixás and goddess of the sea, are associated with various titles of the Virgin Mary, including a Nossa Senhora da Assunção (Our Lady of Assumption) and a Nossa Senhora da Conceição Aparecida (Our Lady of Immaculate Conception) (Câmara Cascudo, 2000; Guimarães de Magalhães, 1974). In Ceará, Oxúm is celebrated on December 7, the same day that the Immaculate Conception is observed in the Catholic religion, while, in Fortaleza, Iemenjá, is associated with Nossa Senhora da Assunção, the patron saintress of Fortaleza, and both are celebrated on August 15 (Souza dos Anjos et al., 2021).

⁹ Religious syncretism in Brazil has a long and complex history, beginning when European colonizers first invaded the continent and ordered Indigenous populations to adopt Jesuit Catholic teachings. Subsequently, enslaved Africans

Cícero Romão Batista (Padre Cícero, 1844-1934) evince a spiritual connection to the semi-arid sertanejo landscape (Walker, 2012). Padre Cícero, affectionately called Padrinho Cícero or Padim Ciço, was a priest from Crato, Ceará, whose teachings emphasized the need for *convivência* (coexistence) with the sertão through attention to balance and reciprocity with the land.¹⁰ His religious and ecological teachings continue to have important influence in Brazil, particularly across the rural zones of Ceará (Ferreira, 2014). In Ceará, religious and ecological understandings coalesce, as water and drought acquire spiritual meanings through their association with Afro-Brazilian orixás and Catholic saints.

While living in Quixeramobim, I observed how rural dwellers often interweave religious beliefs with questions of water quality and quantity, placing access to quality water in God's hands. Uncertainty of the upcoming rainy season, for example, is often justified through acknowledgement of God's omniscience: in Maraquetá, a federal settlement in Quixeramobim, the woman who would host me during my stays observed how "*Só Deus sabe*" ("Only God knows") how the winter will be, as we discussed the rain that December and how we would soon be entering the rainy season (personal correspondence, December 27, 2021). For most people with whom I spoke, rainwater is sent by God. This belief influences how people view the rainy season and water quality. On the night of *o Dia do Evangélico*¹¹ in 2022, for example, the municipal government of

who had been forcibly removed from their homelands developed sophisticated strategies to maintain their cultural and religious teachings, including the swapping of the names of orixás for Catholic saints. Romão (2018, p. 378) explains, "In the end, the [contemporary] religious mixture in Brazil can be understood as a synthesis that occurred at the crossroads of transnational and translational survival strategies."

¹⁰ Greenfield (2013) notes that Padre Cícero espoused a type of popular or folk Catholicism, which often conflicted with the official teachings of the Roman Catholic Church. Yearly pilgrimages to Juazeiro do Norte, where Padre Cícero resided, began during the priest's lifetime and continue today, as more than two thousand pilgrims travel to the city in November to visit the giant statue of Padre Cícero built in the 1970s (Greenfield, 2013). While the Brazilian Catholic Apostolic Church declared Padre Cícero a saint, he has yet to be beatified by Roman Catholic Church. The Roman Catholic Church actually suspended Padre Cícero in 1894 due to accusations of heresy and mysticism, though the priest was eventually pardoned by the Church in 2015 (G1 CE, 2015)

¹¹ Evangelical Day is a national holiday in Brazil celebrated on April 16.

Quixeramobim held a public event in the Plaza of the *Prefeitura* (City Hall), during which the *vice prefeito* (vice mayor) of Quixeramobim led a prayer for rain to fill the Quixeramobim Reservoir. On that day (April 16, 2022), the Quixeramobim Reservoir was at 7.89 percent and a month and a half remained of the rainy season (Hydrological Portal of Ceará). The perception of rainwater's quality is also linked to the divine. When asked why they preferred to drink rainwater over other water sources, the majority of people with whom I spoke explained that rainwater is “*água boa*” (“good water”) that is “*mandada por Deus*” (“sent by God).” As one rural dweller noted when asked about the rainwater in her cistern, “*Graças a Deus hoje tem água limpa para beber*” (“Thanks to God, today we have clean water to drink”) (interview, May 11, 2022). Cultural and religious dimensions of water substantiate understandings of the lived experience of water insecurity and must be considered along with empirical measurements of water quantity and quality to assess what access to quality water means in different cultural contexts.

1.2.4 Human-Technology Relations

Technology mediates relationships with water and experiences of water (in)security through activities such as storing, transporting, and measuring. In this sense, technology refers to the material artifacts or devices through which human capabilities are extended (Lawson, 2008). Of the four relations through which experience is mediated through technology described by Ihde (1977, 1990), hermeneutic and background relations foreground human-technology-water relations. Hermeneutic relations involve the ways that we interpret the world through technology, while background relations refer to the ways technology constitutes part of our everyday experience.

Hermeneutic relations form the basis of interpreting meteorological and hydrological conditions in Ceará. For example, meteorologists at FUNCEME use technological devices to measure sea surface temperatures (SST), develop inter- and intra-seasonal forecasts, and predict and track the transition from La Niña to El Niño and back again. The use of such devices influences meteorologists' understanding of climate and weather patterns, which, in turn, helps to shape interpretations of current and future hydrological conditions and management decisions in response to those conditions. Likewise, my use of the Hydrological Portal of Ceará impacts my understanding of current hydrological conditions in Quixeramobim and other regions of Ceará. I frequently use the portal to monitor the current water level of the Quixeramobim Reservoir and have used the data available to interpret changes in water supply across time (Figure 1.2). While most people I met in Quixeramobim do not check the Hydrological Portal of Ceará as frequently as I do, the technologies used to measure the water level of the Quixeramobim Reservoir impact their interpretations of their own water situations. As of March 14, 2024, the Quixeramobim Reservoir was lacking only 83 cm of water to overflow, an event that took place for the first time in 11 years in April 2023. The anticipation of seeing the Quixeramobim Reservoir overflow increases senses of water security, even though most households in diffuse rural communities do not receive water from this source.

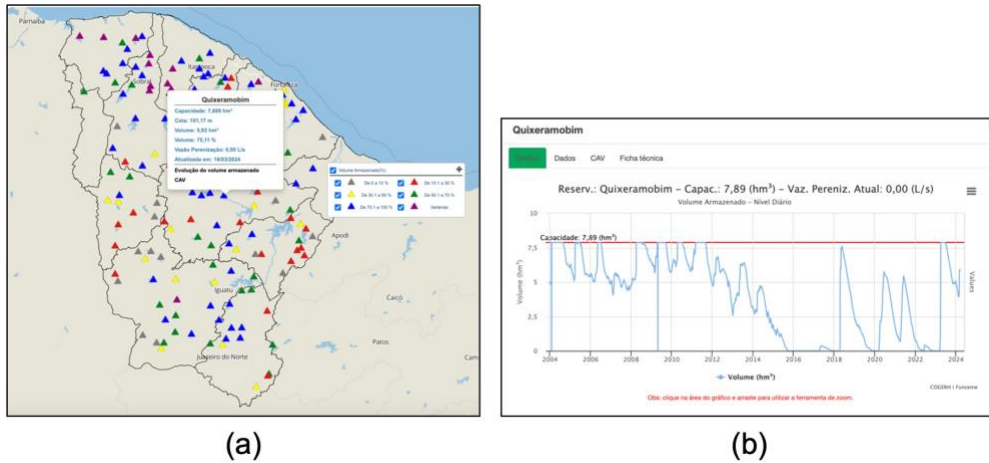


Figure 1.2 Hermeneutic water technology relations through the Hydrological Portal of Ceará. (a) the percent capacity of the Quixeramobim Reservoir on March 16, 2024 and (b) the historic volume of water stored in the Quixeramobim Reservoir from 2004 to 2024. (Source: Hydrological Portal of Ceará, <http://www.hidro.ce.gov.br/>)

The technologies of centralized and decentralized water infrastructure—including reservoirs, water towers, water treatment plants, perennialized rivers, wells, and rain-harvesting cisterns—participate in important background, or everyday, water relations by storing, transporting, and affecting the quality of water for uses including drinking, cooking, cleaning, bathing, animal husbandry, irrigation, and industry. At the same time, these technologies and the infrastructure systems they help constitute are embedded within wider political structures and embody standards and values through their physical structures (Miller, 2020; Winner, 1980). Large-scale water infrastructure (e.g., dams and canals) and water transfers from rural to urban areas often perpetuate inequalities, as the burdens of such projects unequally impact impoverished areas (Anand, 2017; Millington, 2018; Roa-García, 2014). Chapter 2 of this dissertation examines, in part, how contemporary politics lead to water-related inequalities along the Jaguaribe River in Ceará.

In Ceará, large-scale water infrastructure projects (i.e., reservoirs and water transfer systems) have historically been, and continue to be, carried out to respond to drought emergency (Martins et al., 2017). The Cedro Reservoir, which is located in Sertão Central, was the first large-

scale reservoir constructed in Brazil, conceived by the Brazilian Empire in response to the devastating drought in 1877-1879 (Monteiro, 2020). Throughout the 20th century, the modernist paradigm of “*Combate contra a seca*” (“Fight against drought”) guided federal drought policies focused on large infrastructure projects across Northeast Brazil (Alves da Silva, 2007). For example, the Banabuiú Reservoir, the Quixeramobim Reservoir, and the Orós Reservoir (located in the Alto Jaguaribe Sub-River Basin) were constructed as responses to widespread drought in the late 1950s. These large water-infrastructure projects are often associated with the Drought Industry, the term Brazilian journalist, novelist, and playwright Antônio Callado introduced in the 1960s to describe exploitation of drought crisis in the Northeast by politicians for personal gain (Lopes, 2022). More recently, the Castanhão Reservoir, the largest multi-use reservoir in Latin American, was constructed from 1995 to 2002 for water storage and the regulation of the Jaguaribe flood regimes that devastated the cities in the lower areas of the Jaguaribe River Basin (Olimpio et al., 2015). The indignation toward wealthy landowners and corrupt politicians expressed in Callado’s reporting continues to resonate within the cultural memory of Cearenses, as new infrastructure projects, such as the *Malha d’Água* projects,¹² are carried out; deals are made with big businesses regarding irrigation rights; and diffuse rural communities continue to lack reliable water sources for household uses.

¹² Projeto Malha d’Água, or the Water Pipeline Network Project, consists of several infrastructure projects that involve the development of new water management strategies at different scales and major water-transfer pipeline infrastructure for water transfers from strategic reservoirs to urban centers across the state of Ceará. The overall objectives of the program, which includes 34 pipeline systems, are to increase water security, guarantee water quality and quantity for urban areas, increase water available (e.g., by decreasing water losses due to river-aquifer interactions and evapotranspiration in open canal systems), and significantly reduce dependence on and costs associated with water truck programs (SRH, 2023). Project development began in 2016. The project horizon is 25 years and has an expected cost of 9 billion BRL. One of the two systems of the first phase constructed is located in the BRB (Banabuiú-Solonópole Pipeline System). While the projects are premised on increasing water security across the state, they do not contemplate water security of households in diffuse rural communities.

While the implementation of large-scale water infrastructure remains a priority for the State of Ceará, a greater focus on community water management and decentralized, small-scale water infrastructure to increase household water security in diffuse rural communities has developed since the late 20th century. This trend reflects the sustainable development paradigm “*Convivência com o semiárido*” (“Living with the semi-arid region”) that emerged in the 1990s with a greater focus on local sociotechnological solutions (Alves da Silva, 2007). In general, a community water management system is composed of a water source, technology for water storage and distribution (including an electric pump, a water tower or tank, and pipe systems), and houses with or without household water tanks to store water from the community system (Figure 1.3). Water tanks are usually located inside of the house but are depicted outside of the houses in the diagram to indicate their presence. In the rural area of Quixeramobim, all of the houses I visited that had running water and a toilet also had a septic tank, into which black water (i.e., wastewater from toilets that contains fecal matter and urine) flows from the toilet bowl through a drainage system. Families only flush human waste and water down their toilets, while paper and other solid waste is discarded in a trashcan. Gray water (i.e., wastewater that does not contain human waste) from a household’s kitchen sink or washing machine is typically discarded through a PVC pipe into the family’s *quintal* (yard/garden). There are 10 gray water reuse systems installed in rural houses in Quixeramobim (Francisco José Sousa Pinheiro, personal correspondence, May 11, 2023). Water flows from kitchen sink into the system, which is located outside of the house, through a drainage pipe, and the treated water is used for irrigating plants in a family’s *quintal*. Additionally, since 2023, the Antônio Conselheiro Institute (IAC) has collaborated with a subsistence farmer in the rural area of Senador Pompeu, another municipality in Sertão Central, to pilot test a back water reuse system.

At the community level, systems vary by characteristics including water source (e.g., small reservoir, deep well,¹³ *cacimbão*,¹⁴ and/or river), water management entity (the community; the municipal water authority, SAAE; or a third party),¹⁵ the presence or absence of water treatment, the presence or absence of a water tower or communal water tank (*chafariz*), the use of water meters, and the number of households that participated in the system. Across Quixeramobim, I observed various combinations of the modes and means of water management at the community level. In communities without a community-managed water system, individual households or small clusters labor to provide water for themselves. *Carros pipas* (water trucks)—supplied by the Brazilian Army, the municipality, or private operations—also contribute to community-level water infrastructure systems when a community or household lacks a reliable source of water, typically during periods of prolonged drought. Community water systems are not isolated from larger social, political, and environmental processes but rather interact with them to impact water supply, quality, and infrastructure. Regardless of the absence or presence of a community-managed system and the particularities of a given system, almost all households use rainwater stored in household cisterns for drinking and cooking. Cisterns also contribute to community water management systems by storing water delivered by water trucks. I discuss the contributions of household rain-

¹³ According to Cearense State Decree No. 31.077 (December 12, 2012), deep wells are defined as having a depth of at least 50 m (Ceará, 2012, p. 6).

¹⁴ Large, shallow wells called *cacimbões* are also common and are typically dug into floodplains, riverbeds, or reservoir beds to capture surficial water. *Cacimbões* located in riverbeds are typically used during the dry season, when ephemeral streams dry up, while *cacimbões* located in reservoirs provide an alternative water capture method during critical periods when reservoirs dry up.

¹⁵ In some municipalities that have a municipal water authority (SAAE) and in all municipalities where the Water and Sewage Company of Ceará (CAGECE) manages urban water, the Integrated Rural Sanitation System (SISAR) is another possible water management entity. SISAR was created in 1996 by the State of Ceará with foreign investment to address water and sanitation of diffuse rural communities. There are eight SISARs in Ceará. Each SISAR is an autonomous non-profit organization with a regional office with a financial, technical, and outreach division that provide water-management support to the community associations that form part of the federation.

harvesting cisterns to increase water security in decentralized water infrastructure systems in Chapter 4.

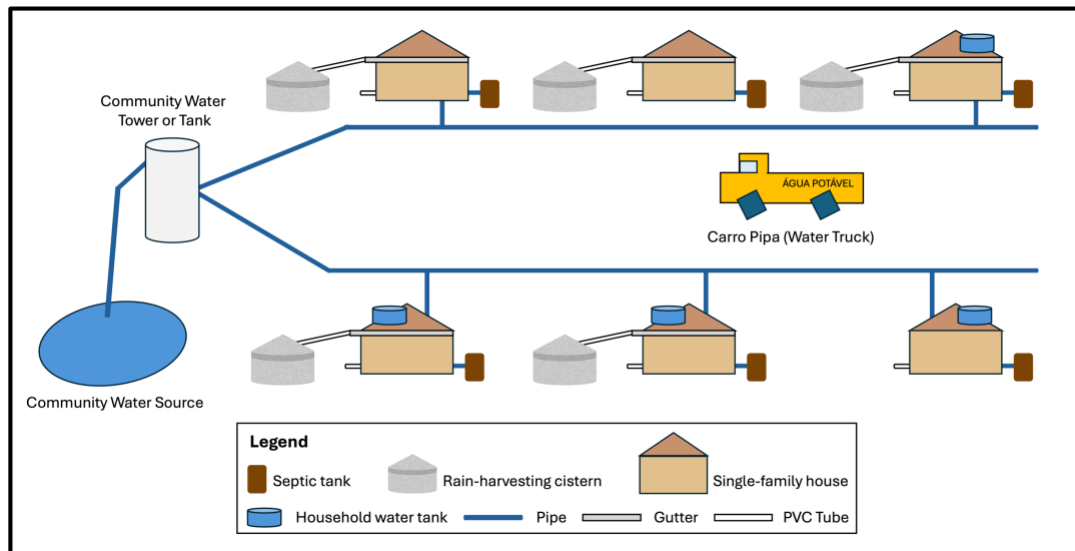


Figure 1.3 Representative diagram of small-scale, decentralized water infrastructure in diffuse rural communities in Ceará, Brazil.

1.2.5 Environmental and Hydrological Processes

Environmental and hydrological processes impact water availability and quality, and water insecurity can be experienced differentially due to factors such as seasonality (Hadley & Wutich, 2009). More than 90 percent of the Ceará is characterized by a tropical semi-arid climate, with low precipitation and high temperatures, rates of evapotranspiration, and spatial and temporal rainfall variability. The majority of the state is characterized by crystalline rock formation with shallow soils, which limits groundwater storage and surface flow retention. Rivers are intermittent, if not perennialized by water stored in medium to large reservoirs, like the Jaguaribe River. Periodic multi-year droughts have long characterized Ceará. Yet rainfall patterns in semi-arid areas, including Ceará, are becoming ever more extreme, with longer dry periods and fewer, but more intense, heavy rainfall events, a process called hydroclimatic intensification (de Oliveira et al., 2014; de Medeiros et al., 2022). Severe drought from 2012 to 2018, for example, greatly increased

stress on limited water resources (Marengo et al., 2017; Pontes Filho et al., 2020). While extreme rainfall events in March and April 2023 helped to recharge important reservoirs throughout Ceará, the events also resulted in declarations of calamity and emergency, extensive property damage, the rupturing of small dams, and other negative impacts, including the isolation of rural communities.

Precipitation in Ceará is influenced by a variety of atmospheric and oceanic systems throughout the year. The primary driver of the rainy season (February to May) is the Intertropical Convergence Zone (ITCZ), with below-average rainfall during this period linked to anomalies in the Atlantic system (Hastenrath & Greischar, 1993; Hastenrath & Heller, 1977). The El Niño-Southern Oscillation (ENSO) also plays a crucial role in rainfall patterns: La Niña normally results in above-average rainfall, while El Niño leads to below-average rainfall (Kayano & Capistrano, 2014). The Madden-Julian Oscillation (MJO) has intraseasonal impacts (Valadão et al., 2017; Vasconcelos et al., 2018). Other climate systems—such as the South American Monsoon System, cold fronts, upper tropospheric cyclonic vortices, quasi-linear convective systems, easterly wave disturbances, and mesoscale convective complexes—contribute to precipitation events throughout the year in various ways (Comin et al., 2021; Ferreira and Mello, 2005, Gomes et al., 2015, Vasconcelos et al., 2018).

Given the impact of rainfall patterns on water supply in Ceará, the State prioritizes work to improve understanding of the interactions of these systems and climate forecasting. Over the past decades, FUNCEME has actively contributed to advancements in this area, including the development of seasonal climate forecasts using dynamical downscaling¹⁶ in the late 1999s and early 2000s, the adoption of an objective forecast system¹⁷ in 2012, and the current use of

¹⁶ Dynamic downscaling resolves global-scale weather conditions at a finer scale to create more spatially detailed climate information. The process is also called regionalization.

¹⁷ Objective forecasts are produced directly from the selected models, without a negotiation process. They are contrasted to consensus forecasts, which add a significant level of subjectivity, as a group of forecasters determines a

probabilistic forecasting¹⁸ (Eduardo Sávio Martins, personal correspondence, October 25, 2022). However, it is not guaranteed that improvements in forecasting lead to better informed and more equitable decisions, as decisions may depend not only on the forecast's objectivity but also on factors such as users' understanding of uncertainty in forecasts and personal or professional interests (Morss et al., 2008). While this dissertation does not directly analyze climate patterns, the social and hydrological impacts of drought on lived experience in Ceará saturate the chapters.

Beyond rainfall patterns, water's materiality and biophysical characteristics play active roles in the lived experience of water insecurity and the transformation of sociopolitical structures (Bakker, 2012, p. 617). Focusing primarily on the movement of liquid water, hydrosocial analyses have described how water flows in accordance with the movement of capital (Linton & Budds, 2014). However, work toward more equitable water governance requires greater attention to the different forms water takes and water's transformations through processes such as infiltration and evaporation (Ballesterio, 2019). A key relationship for the water management of surface water is that between liquid water and water vapor, as mediated through the dynamics of evaporation. The integration of hydrological methods into hydrosocial analyses can further insight into how hydrological processes, such as evaporation, are hydrosocial processes impacted by factors including air temperature, water flow rates regulated by allocation decisions and water uses, and the presence of built infrastructures (e.g., reservoirs and canals). This dissertation contributes to understandings of evaporation from reservoirs in semi-arid regions through evaporation studies carried out in key reservoirs in the municipality of Quixeramobim, detailed in Chapter 3.

single forecast through consensus. In the negotiation process, social and political pressures (e.g., the need to establish a forecast that appeases farmers or state agencies) may drive outcomes.

¹⁸ Probabilistic forecasting provides the probability that an event (rainfall) of a specific or range of magnitudes may occur in a specific region (the state of Ceará) in a particular time period (e.g., 14 days, 21 days, 45 days, or a trimester).

Water relations and water insecurities in Ceará emerge through the interactions among social and political relations, cultural meanings and values of water, the relations between people and technology, and hydrological processes. The lived experience of water insecurity encompasses the everyday ways people navigate these processes as they work to secure access to quality water and improve their quality of life.

1.3 The Exploration of Embodiment Across Disciplines

I employ embodiment across the critical social sciences, hydrology, theatre and performance, and philosophy of technology to explore the lived experience of water insecurity and the different processes through which that experience is shaped in Ceará. When we expand the concept of the body to include water bodies, embodiment becomes a transdisciplinary method, a way to examine both the lived experience and larger socrionatural relations that make up water insecurity. The observable characteristics of water and water insecurity can be understood as particular embodiments of these intertwined relationships. The methods used to integrate different disciplinary-specific meanings of embodiment include ethnographic methods (semi-structured interviews; unstructured interviews; and co-performative witnessing during homestays, community and institutional meetings, and everyday moments), archival research, community-engaged theatre, qualitative and quantitative hydrological assessments, and the application of a mixed-methods household water insecurity questionnaire. The methods and data management processes for human-subject research were approved by the University of Georgia Institutional Review Board through the Office of Research through two projects: PROJECT00000439, “The Multiple Dimensions of Water in a Water Insecure Place,” and PROJECT00005299, “Household-Level Water Security in Ceará, northeast Brazil.” Across the chapters of this dissertation, the

exploration of embodiment facilitates the integration of different knowledge types to foster a more holistic understanding of the chronic water insecurities and inequities in Ceará.

This introductory chapter and the other chapters of this dissertation draw on two years of living and working in Quixeramobim, Ceará. I moved to Quixeramobim in October 2021 after having stayed two months in Fortaleza, where I spent time with the theatre troupe Pavilhão da Magnólia and planned the logistics of my long-term fieldwork with Dr. Eduardo Sávio Martins of FUNCEME. When I arrived in Fortaleza in August of that year, the newest research fellow at FUNCEME, I was planning on moving to Limoeiro do Norte in the Jaguaribe Valley to carry out my research. However, given that FUNCEME, in collaboration with the French Agricultural Research Center for International Development (CIRAD), was actively planning pilot studies for Projeto Sertões in three municipalities of Sertão Central—Quixeramobim, Piquet Carneiro, and Milhã—Eduardo and I decided that it made the most sense for me to carry out research in the region, so that I could contribute more directly to Projeto Sertões and, in turn, the project's initiatives could support my work. This decision meant that I would be moving to a region I knew very little about and where I initially had no contacts.

Once I arrived in Quixeramobim, Paulo Ferreira, the manager of the regional office of COGERH in Quixeramobim at the time, helped me make contacts and learn about the municipality. Thanks to his help and support, during my first months in Quixeramobim, I established working relationships with people at the Antônio Conselheiro Institute (IAC), the Institute of Art, Culture, Leisure, and Education (IARTE), Integrated Rural Sanitation System (SISAR), the Rural Workers Union of Quixeramobim, COGERH, and SAAE. He also helped arrange my first homestay with a family in Maraquetá for early November and subsequent community visits throughout the municipality. Paulo's generosity and interest in my research,

researched I hoped would contribute to improving water security in the rural area of Quixeramobim, were fundamental to carrying out the methods I had proposed.

The methodology I developed to study the dynamics of water insecurity in the rural area of Quixeramobim includes ethnographic methods, hydrological methods, performance as theory and method, and the application of a mixed-methods questionnaire. My ethnographic methods included interviews; homestays; and participation in daily life, community and municipal meetings, and diverse celebrations and events. I carried out semi-structured and informal interviews with rural dwellers; representatives from non-government organizations including IAC and IARTE; Rural Workers Union board members; municipal government representatives including the Secretary of Agricultural and Water Resources; managers and employees at SISAR, COGERH, and SAAE; and state government employees. I was welcomed to stay with families in several communities in Quixeramobim, including Maraquetá, Cachoeirinha, Mearim II, and Campinas, and with a family in a rural community in the municipality of Piquet Carneiro. The hydrological methods I used are detailed in Chapter 3.

My performance methods included organizing community-engaged theatre workshops in the communities of Jundiá and Quilombo Mearim during which theatre games developed by Augusto Boal (1992) were used to explore past, present, and future water relations. In Quilombo Mearim, community members and I devised the play *Mudança da água no Quilombo Mearim* (*Water Changes in Quilombo Mearim*), which traces the community's past and present water realities and its visions for its water future. The cast included youth, adults, and elders from the community, and the play was performed in Quilombo Mearim on my last night in Quixeramobim to an audience that included representatives from social movements, the public water authority SAAE, and the municipal government. The play centered local voices and communicated local

goals to people in positions of power. While I do not include a chapter dedicated to the play, the devising process further enriched my understanding of past and present water challenges in the region.

In addition to these methods, I developed and applied a mixed-methods household water insecurity questionnaire, building on the Household Water Insecurity Experience (HWISE) survey developed for another region of Ceará (Jepson et al., 2021; Tomaz et al., 2020). With the help of six research assistants (two undergraduate students studying environmental engineering at the Federal Institute of Ceará – Quixadá (IFCE—Quixadá), two undergraduate students studying geography at IFCE—Quixadá, one recent IFCE—Quixadá geography graduate, and one researcher at FUNCEME), the survey was applied in 52 communities at the end of the 2022 rainy season (May – July) and at the end of the 2022 dry season (November 2022 – January 2023). The survey work provided me with the opportunity to intimately know the *carroçais* (dirt roads) and lived realities throughout the rural area of Quixeramobim. This dissertation does not include the statistical analysis of the survey applications, but quotes and perspectives shared during structured interviews are used as data and have helped shape my understanding of Quixeramobinense water relations. Additional details on the survey work, including the sample size, community selection, and the data collection process are included as an appendix at the end of the dissertation.

Chapter 2 of this dissertation explores the embodiment of Northeast Brazilian culture, identity, politics, and climate patterns through two experimental performance pieces by contemporary Cearense artists. The chapter is based on work I did before my long-term fieldwork in Quixeramobim and reflects the relationships I have with Pavilhão da Magnólia and Chico Oliveira, a multi-modal performance artist from Quixeré in the Jaguaribe Valley. The chapter builds on works that recognize the power of performance to explore intersecting sociopolitical and

environmental injustices in creative, imaginative ways (Woynarski, 2020). I argue that the water relations along the Jaguaribe River and across the sertão embodied in the pieces connect regionalist imaginaries from 20th century Northeast Brazil to contemporary struggles and water relations. The chapter explores how the ebbs and flows of the Jaguaribe River are performed in *Dramaturgias da Água e da Seca (Water and Drought Dramaturgies, 2018)* by Pavilhão da Magnólia and *A retirante (The Drought Migrant, 2020)* by Chico Oliveira and Débora Ingrid, as well as the interconnections among the artists and me, a researcher and performance artist from the United States. By foregrounding the performances' engagement with water's presence and absence, I highlight the performances' ability to holistically critique chronic water inequities that encompass the diverse meanings and values of water in Ceará and across Northeast Brazil.

In Chapter 3, I use embodiment to conceptualize the processes that contribute to the hydrological dynamics of water bodies by assessing evaporation rates from the Cachoeira do Germano and São Miguel Reservoirs, two multi-use reservoirs in Quixeramobim, Ceará. With colleagues at COGERH, FUNCEME, and the University of Georgia, I developed a method to measure open water evaporation using floating minipans, which I adapted from the methods used by Caissie (2016) and Maheu et al. (2014) to measure river evaporation. Analysis of variance (ANOVA) was used to calculate evaporation loss coefficients for a general linear model (multiple regression) based on the reservoir, measured rates of water loss (g/hr), and minipan and climatic variables. In future work, the values derived from the minipan measurements will be compared to those using daily Class A pan measurements from a pan located in the same region as the Cachoeira do Germano Reservoir. Additional, climatic data from the Quixeramobim Weather Station will be used to calculate reservoir evaporation rates for daily, monthly, and yearly time periods.

Chapter 4 is an ethnographic exploration of the impacts of federal rain-harvesting cistern programs on household water security. I extend Anand's (2017) concept of the hydraulic citizenship—defined as the ability of residents to be recognized through legitimate water services—to the dynamics of decentralized water infrastructure in diffuse rural communities. My analysis centers the embodiment of particular social values, political values, and regional hydrological characteristics by government-sponsored cistern programs and the cisterns that are constructed through these programs. The chapter draws on my ethnographic research as well as on digital archives, including news reports, blogs, and cistern handbooks. The infrastructure lifecycle (i.e., conception, budgeting, design, implementation, and monitoring and maintenance) frames my analysis of the rain-harvesting cistern, a social technology that increases household water security of impoverished rural families and embodies *conscientização* (critical-consciousness raising), the dynamics of gendered water roles, and historically contextualized water values through its materiality and social and hydrological embeddedness.

My conclusion chapter interrogates the integrativeness of this dissertation and the value of integrating across anthropology, hydrology, philosophy of technology, and performance studies to deepen understandings of water insecurity. I argue that the use of embodiment as a boundary object facilitates the integration of diverse ways of knowing to promote a more holistic approach to studying the lived experience of water insecurity and the intertwining socionatural relations through which this lived experience emerges differentially in Ceará. I bring attention to inequitable experiences of water access, water quality, and water-related stress that I was witness to through my observations and through the stories I was told. I also assess my responsibility and efforts toward increasing social equity in Quixeramobim, particularly given my positionality as a white (Jewish) researcher from the Global North and eventually, as an honorary citizen of

Quixeramobim. My ongoing commitment to Quixeramobim and the families who continue to offer me generosity and kindness forms part of my ethics and praxis. I conclude by emphasizing that water-related challenges in Quixeramobim and throughout Ceará will continue to evolve due to intertwining dynamics of climate change, policy priorities, small and large-scale water infrastructure, social relations and inequalities, and diverse water values. I argue that greater attention to the recursive relationships between these dynamics and the lived experience of water insecurity of traditionally marginalized groups, including the rural poor, is essential to create more just water futures.

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CHAPTER 2

THE PERFORMANCE OF WATER AND NORTHEAST BRAZILIAN IMAGINARIES

ALONG THE JAGUARIBE RIVER OF CEARÁ, BRAZIL¹⁹

¹⁹ Seigerman, C. K., to be submitted to *Theatre Research International*.

Abstract

Drought-related suffering and the oppression of the rural poor form part of the regional imaginary fomented by Northeast Brazilian regionalist theatre and the literary, political, and sociological movements of the early 20th century on which it draws. Despite shifts toward more democratic water policies and greater attention to environmental sustainability by state and federal governments in Brazil toward the end of the 20th century, drought and conflicts over water remain ever-present in contemporary struggles and in Northeastern cultural imaginaries. In this article, I examine how experimental performance pieces by contemporary artists in Ceará, Northeast Brazil, draw on Northeastern regionalist themes to confront historically situated uneven social, political, and ecological relations that shape inequities in the Cearense sertão, or hinterlands. *Dramaturgias da Água e da Seca (Water and Drought Dramaturgies, 2018)* by Pavilhão da Magnólia and *A retirante (The Drought Migrant, 2020)* by Chico Oliveira and Débora Ingrid position Northeastern water imaginaries along the Jaguaribe River in Ceará. The artists are connected by collaborations, the Northeast Brazilian imagery they use, the water inequities they critique, and the physical water that flows from the Jaguaribe Valley to Fortaleza. Performing water's presence and absence, *Water and Drought Dramaturgies* and *The Drought Migrant* critique chronic water inequities that encompass cultural, spiritual, and climatic meanings of water in Ceará and across Northeast Brazil.

2.1 Introduction

Terra rachada, literally “cracked earth” in Portuguese, refers to the dried, cracked earth of barren riverbeds and reservoirs that dominate landscapes across Northeast Brazil during extended periods of drought. The broken earth forms part of the imaginary of Northeast Brazil, an imaginary that began to take shape in the early 20th century through regionalist literary, political, and

sociological movements and that was fomented by regionalist theatre beginning in the 1940s.²⁰ It is a symbol of the suffering of impoverished *flagelados* or *retirantes* (drought migrants), who would flee their homes, traveling on foot in search of water, food, and opportunities in large cities hundreds of kilometers away. The broken earth is also a testament to the region's predominate semi-arid climate, characterized by distinct rainy and dry seasons; low rainfall; and high temperatures, evapotranspiration rates, and spatial and temporal rainfall variability. The cracked earth's presence and water's absence are entangled with the power-laden dynamics of present-day decentralized water management strategies. They embody the interrelations among drought-related suffering and the past and present oppression of the rural poor in Northeast Brazil.

In this article, I examine how experimental performance pieces by contemporary artists in Ceará, Northeast Brazil, draw on Northeastern regionalist themes and imaginaries, including terra rachada, to confront historically situated uneven social, political, and ecological relations that shape inequities in the Cearense sertão, or hinterlands. Theatre and performance are apt for exploring intersecting sociopolitical and environmental injustices in creative, imaginative ways.²¹ Identity, culture, and memory are embodied and transmitted through performances,²² and attention to the performance of water can expand understanding of the dynamic and myriad relationships people have with water and the environment.²³ Theatre and other types of performance situate bodies of water in a physical yet ephemeral space, “balancing between phenomenal and conceptual.”²⁴ *Dramaturgias da Água e da Seca (Water and Drought Dramaturgies, 2018)* by

²⁰ Durval Muniz de Albuquerque Jr., *A Invenção do Nordeste e Outros Artes* (São Paulo: Cortez Editora, 2011).

²¹ Lisa Woynarski, *Ecodramaturgies: Theatre, Performance and Climate Change* (Palgrave Macmillan, 2020), p. 8.

²² Yvonne Daniel, *Dancing wisdom: embodied knowledge in Haitian Vodou, Cuban Yoruba, and Bahian Candomblé* (Urbana and Chicago: University of Illinois Press, 2005); Diana Taylor, *The Archive and the Repertoire: Performing Cultural Memory in the Americas* (Durham: Duke University Press, 2003); Diana Taylor, ‘Performance and/as History’, *TDR (1988-)*, 50, 1, (2006) pp. 67-86.

²³ E.J. Westlake, ‘Editorial Comment: Water’, *Theatre Journal*, 71, 4 (December 2019), pp. xi-xiii.

²⁴ Natalie Katsou, ‘Theatre Heterotopias: Sea on Stage’, *Body, Space & Technology*, 19, 1 (February 2020), pp. 1-16, p. 2.

Pavilhão da Magnólia and *A retirante (The Drought Migrant, 2020)* by Chico Oliveira and Débora Ingrid position Northeast Brazilian water and drought imaginaries within the Cearense context, locating these imaginaries along the shores of Jaguaribe River, which traverses approximately 680 kilometers of the semi-arid sertão of Ceará.²⁵

Like most rivers in the semi-arid region of Northeast Brazil, the Jaguaribe River is intermittent, meaning that it does not flow all year long but rather many of its tributaries dry up as the dry season advances and when drought persists in the region. The Jaguaribe River is considered the most important river in Ceará, its watershed occupying 50 percent of the state's territory and its water used for human and animal consumption, large-scale irrigation, and industry in the Jaguaribe Valley and state capital, Fortaleza.²⁶ Because of its grandeur and ephemeral nature, the Jaguaribe River once donned the sobriquet “The World’s Largest Dry River.”²⁷ Yet the river is now perennialized, its flow made continuous yearlong along different sections by a network of large-scale reservoirs constructed in the 20th and early 21st century, whose water is currently released based on collective decisions made by members of local river-basin committees and the State of Ceará.²⁸ The flow of water through the Jaguaribe River depends on climate, land and water

²⁵ The analysis of *Water and Drought Dramaturgies* draws from the recording of the October 2018 performance, the updated March 2019 script shared with me by Pavilhão da Magnólia, and interviews and ongoing conversations with members of Pavilhão da Magnólia. The analysis of *The Drought Migrant* is based on the film and interviews with Débora and Chico.

²⁶ Alexandre Castro, Anatarino Torres da Costa, Jose Alves Carneiro Neto, João Silvio Dantas de Moraes and Vanda de Claudino-Sales, ‘Expedição científica ao alto curso do Rio Jaguaribe (Ceará): identificação da nascente do possível maior rio temporário do mundo’, *Caderno de Geografia*, 30, 63 (2020), pp. 956-974, <https://doi.org/10.5752/p.2318-2962.2020v30n63p956>.

²⁷ *Jornal O Povo*, Fortaleza (1976), cited in Gabriel Pereira de Oliveira and Eurípedes Antonio Funes, ‘As disputas pelas águas daquele que já foi “o maior rio seco do mundo”: o rio Jaguaribe e as estruturas hidráulicas no semiárido brasileiro nos séculos XIX e XX’ in Bruno Capilé, Fabiula Sevilha, Gabriel Pereira de Oliveira and Vladimir Sánchez Calderón, orgs., *As Margens do Progresso Os Rios e a Modernização nas Sociedades Latino-Americanas* (Maceió, AL, Brazil: Editora Olyver, 2019), pp. 57-75, p. 57.

²⁸ Maria Carmen Lemos, Bruno Peregrina Puga, Rosa Maria Formiga-Johnsson and Cydney Kate Seigerman, ‘Building on adaptive capacity to extreme events in Brazil: water reform, participation, and climate information across four river basins’, *Regional Environmental Change*, 20, 53 (April 2020), pp. 1-13. <https://doi.org/10.1007/s10113-020-01636-3>

use, and the politics of water allocation, highlighting its socionatural (i.e., part social, part natural) character.²⁹ Pavilhão da Magnólia and Chico and Débora explore socionatural Cearense landscapes through their performance pieces. The performances attest to and challenge drought-related suffering of the rural poor—suffering often considered innate to the semi-arid sertão—through embodied practice that incorporates the ephemeral force, flow, and fluidity of the Jaguaribe River and the emotional connections of Cearenses to their land and waterscapes.

Water and Drought Dramaturgies and *The Drought Migrant* were developed in the context of prolonged drought and perpetual socioecological crisis in Ceará. The performance *Water and Drought Dramaturgies* is the first of Pavilhão da Magnólia's two-part performance project "Water and Drought Dramaturgies." In this first performance, Pavilhão da Magnólia brings Ceará's contemporary hydrological crisis into dialogue with the devastation of the infamous drought of 1915, during which the Cearense government forced drought migrants into concentration camps in order to prevent them from reaching the urban area of Fortaleza.³⁰ In 2018, and as Ceará faced its seventh consecutive year of drought, Pavilhão da Magnólia commenced their research-based theatre production based on the Northeastern regionalist novel *O Quinze* by Rachel de Queiroz (1930), which includes references to the concentration camps and tells the story of a family of drought migrants and their arduous journey out of the sertão toward hope of food and opportunity during the 1915 drought in Ceará. Pavilhão da Magnólia incorporated contemporary conflicts of water distribution along the Jaguaribe River and to Fortaleza into *Water and Drought Dramaturgies*, which was performed in October 2018 in the persistent presence of long-term drought impacts. The performance project's overarching critique of contemporary

²⁹ Noel Castree, 'Socializing nature: theory, practice, and politics', in Noel Castree and Bruce Braun, eds., *Social Nature: Theory, Practice, and Politics* (Malden, MA: Blackwell Publishers, 2003), pp. 1-21.

³⁰ Frederico de Castro Neves, 'Curral dos Bárbaros: os Campos de Concentração no Ceará (1915 e 1932)', *Revista Brasileira de História*, 15, 29 (1995), pp. 93-122.

sociopolitical, economic, and ecological inequalities connects Pavilhão da Magnólia's work to Northeast Brazilian regionalist theatre of the 20th century.

The performance of *Water and Drought Dramaturgies* at Pavilhão da Magnólia's rehearsal and performance venue, Casa Absurda, marked the last of the group's "experiments" as part of the *Laboratórios de Criação* (Creation Laboratories), organized by O Porto Iracema das Artes Art School of the State Government of Ceará.³¹ The performance is characterized by discrete moments that jump between excerpts from *O Quinze* and situations that describe contemporary water politics in the Jaguaribe Valley. Directed by Miguel Vellinho, *Water and Drought Dramaturgies* created moments in two spaces of Casa Absurda. The first part of the performance occurred in the well-lit, open-air antechamber, where the actors, shoeless and wearing black t-shirts and pants, engaged with the audience through acts of water sharing. To transition to the second space, the theatre of Casa Absurda, audience members were invited to walk across the terra rachada created by the actors (discussed in Section 2.5) and through a narrow hallway into the theatre, which was transformed into a "shared universe of drought."³² The soft lighting of the opening scene was replaced by the darkness, harsh spotlight, and strobe lights of this universe, in which the actors interpreted characters from *O Quinze*, contemporary businesspeople, a dying Mother Earth, and

³¹ O Porto Iracema das Artes is associated with the Cearense Secretary of Culture and managed, in part, by the Dragão do Mar Institute. The Creation Laboratories "[are] spaces for experimentation, research, and development of cultural projects in five languages: Visual Arts, Cinema, Dance, Music and Theater" (Porto Iracema, <http://www.portoiracemadasartes.org.br/laboratorios-de-criacao>, accessed 10 December 2020). As Paulo Sérgio Bessa Linhares explains in *Laboratórios de Criação: Regulamento de Teatro, Ano letivo 2020* (Fortaleza: Governo do Estado do Ceará Secretaria da Cultura, 2020): The artists whose proposals are selected receive both financial, institutional, and professional support, which includes guidance from a professional mentor, a monthly stipend, and publicity for meetings and performances related to the project. A major objective of the Laboratories is to help the artists develop their craft, explore unfamiliar or new methods, and realize the proposed project. Research, creation, and experimentation are fundamental to the Laboratories. In 2018, Pavilhão da Magnólia formed part of the Laboratories' sixth cohort, made up of 22 projects selected out a record number of 425 submitted proposals and through a three-round process carried out from February to May 2018.

³² Interview with Silvanne Lima, December 2020.

rural dwellers and performed other scenes with *bonecos*³³ and animal bones. The remainder of the performance occurred within this drought universe, and darkness was used to transition between the disparate scenes, which jump across time—from the 1915 drought described in *O Quinze* to the 2012-2018 drought—yet remain tied to the Cearense landscape to critique regional drought politics.

Through experimentation with the artistic languages of theatre, puppetry and animation, dance, and music, the independent short film *The Drought Migrant* tells and embodies the story of a young girl who dies along the shores of the dried out Jaguaribe River during severe drought in the indeterminate past.³⁴ Storytelling frames the film, as Débora interprets the role of the narrator, a young woman who recounts the story of the young drought migrant, a story she discovers by following the sounds of a heartbeat. The heartbeat guides Débora to an antique book, which Débora opens to find the story hand-written on loose sheets of paper. Filmed in a typical house of poor rural dwellers—with a clay tile roof, wooden floors, and the paint on the walls worn from time—the short film invokes a mixture of puppetry, non-puppetry performance, and narrative to tell the story of the drought migrant. The audience listens to and watches the story of how, during a day of fishing on the Jaguaribe River, a solitary fisherman retrieves the skeleton of the drought migrant, which had spent countless years buried beneath the river’s current. The skeleton gains vitality and chases the fisherman to his modest home in the sertão, where she is reincarnated after the fisherman untangles her bones and she drinks the fisherman’s tear during his slumber. Concluding with the

³³*Bonecos*, a kind of puppetry common in Ceará and throughout Northeast Brazil is considered intangible national heritage and part of the folk tradition of the Northeast Brazil.

³⁴ The short film premiered at the 30th Ciné Ceará, an annual Ibero-American Film Festival, in December 2020 as a part of the category “Olhar do Ceará” (The Cearense Perspective), which was held virtually and in-person in Fortaleza from December 5-11, 2020.

hope of shared prosperity by the fisherman and woman along the Jaguaribe River, the film foregrounds both the sorrow and vitality that characterize life in the Northeast.

Long-term drought impacts, including low reservoir levels and decreased agricultural production, continued into 2020, comingling with the Covid-19 pandemic to threaten rural livelihoods and families. Within this turmoil, Chico and Débora, who grew up and continue to reside in the rural interior of Ceará's Jaguaribe Valley, created *The Drought Migrant*, placing themselves into a sertanejo cosmos that blends the real with the fantastic, with folklore, and with religious imageries on the shores and in the depths of the Jaguaribe River. The film project brings together the lived experience and artistic vision of the four crew members, who are from Russas and Quixeré, two small cities of the Jaguaribe Valley. Working as co-directors and actors, Débora and Chico conceptualized the film and carried out production with photographer Mauro Angeli and costume designer Joyce Barbosa. Evoking the cultural memory of the crew's relatives and the crew's lived experience during drought cycles in the sertão, the film highlights the watery dynamics of life and death that characterize life in the sertão. While Chico and Débora, like Pavilhão da Magnólia, embody the struggles of historically marginalized rural dwellers through performance, they rely more-so on the embodied memory along the Jaguaribe River transmitted by their own family members of past generations.

The two groups of artists are connected not only by the use of the Jaguaribe River in their works but also by the physical water that flows through the Jaguaribe River and the network of performance artists in Ceará, made visible by the Cultural Map maintained by the Cearense State Secretariat of Culture. Water stored in and released from the Castanhão Reservoir, the largest multi-use reservoir in Latin America, is often diverted from the Jaguaribe River—away from the homes of Chico, Débora, and others in the Jaguaribe Valley—to an integrated system of canals

and dams to provide water to Fortaleza, where the members of Pavilhão da Magnólia reside. At the same time, the artists know and actively collaborate with each other, including during the production of *Water and Drought Dramaturgies*. This article explores the performance of the dynamic flows of the Jaguaribe River in *Water and Drought Dramaturgies* and *The Drought Migrant*, as well as the interconnections among Pavilhão da Magnólia, their contemporaries in the rural interior, and me (a researcher and performance artist from the United States). The past and present water relations along the Jaguaribe River and in the sertão embodied in the pieces connect regionalist imaginaries from 20th century Northeast Brazil to contemporary water struggles and water. Focusing on the performances' engagement with the presence and absence of water, this article highlights the performances' ability to holistically critique chronic water inequities that encompass the dynamic cultural, climatic, political, and spiritual meanings of water in Ceará and across Northeast Brazil.

2.2 Northeast Brazil and its Imaginaries

Drought is deeply implicated in the formation of Northeast Brazil. While drought has long impacted the daily lives of those living in the region now considered the Brazilian semi-arid region, until the early 20th century, the semi-arid region (corresponding to most of the present-day region of Northeast Brazil) and the Amazon were grouped together as the North. The transformation of the 1877-79 drought into “The Great Drought” reflects how, in the late 19th century, Northern elite began to use drought in discourse in order to bring attention to the region on the national level.³⁵ In 1908, Northeast Brazil's identity as distinct from the Amazon became more concrete through

³⁵ Durval Muniz de Albuquerque Júnior, ‘Palavras que calcinam, palavras que dominam: a invenção da seca do Nordeste’, *Revista Brasileira de História*, 15, 28 (1995), pp. 111-120.

the establishment of the Federal Inspectorate of Works Against Droughts (IFOCS).³⁶ The geographical concept of Northeast Brazil subsequently emerged in the 1920s based on notions of nostalgia and tradition and as a reaction of Northern elites to the nationalization and modernization strategies developing in southern states.³⁷ The Northeast was eventually defined as an official geopolitical region by the Brazilian Institute for Geography and Statistics (IBGE) in the 1960s and is composed of nine states: Alagoas, Bahia, Ceará, Maranhão, Paraíba, Pernambuco, Piauí, Rio Grande do Norte, and Sergipe.³⁸

While the Northeast encompasses great cultural, economic, and ecological diversity, its socioecological landscapes are often homogenized by regionalist themes. Sarzynski lists several regional themes portrayed in literature, film, and political discourse used to define the Northeast: “misery, poverty, violence, inequality, climatic harshness, folk religiousness, the nonwhite, and the nonmodern.”³⁹ The themes underpin the trope of the Northeast through symbolic characters or caricatures, including the famished drought migrant; the violent *cangaceiro* (bandit); and the corrupt *coronel* (wealthy landowner who controlled local political spheres).⁴⁰ At the same time, while the Northeast encompasses both coastal and interior areas, the struggles and modes of survival of Northeasterners are most often situated within the rural interior of the sertão. The sertão is characterized by the scrubby plants and animals endemic to the Caatinga ecoregion. Caatinga

³⁶ Durval Muniz de Albuquerque Júnior, Laurence Hallewell (trans.) ‘Weaving Tradition: The Invention of the Brazilian Northeast’, *Latin American Perspectives*, 135, 31(2), (March 2004), pp. 42-61. <http://doi.org/10.1177/0094582X03261187>.

³⁷ Durval Muniz de Albuquerque Jr., *A Invenção do Nordeste e Outros Artes*.

³⁸ The majority of the municipalities that make up the states of Northeast Brazil form part of the Brazilian semi-arid region and the Drought Polygon (*o Polígono das Secas*), a geopolitical region initially established in 1946 and formalized by law in 1968 (Decree-Law No. 63.778, December 11, 1968).

³⁹ Sarah Sarzynski, *Revolution in the Terra do Sol: The Cold War in Brazil* (Stanford, CA: Stanford University Press, 2017), p. 14.

⁴⁰ Sarah Sarzynski, ‘Introduction: Tropes of *o Nordeste*: Contested Visions of the Region During the Cold War’, *Revolution in the Terra do Sol: The Cold War in Brazil* (Stanford, CA: Stanford University Press, 2017), pp. 1-23.

means “white forest” in the indigenous Tupi language.⁴¹ Unique to the Brazilian semi-arid region, the Caatinga embodies its name during the dry season, when the shrubs that become green and lush during months of rain turn a grayish white to survive until the rains return. The harshness of the dried sertanejo landscape and the suffering of those who inhabit it were visualized by novels such as *A Fome* by Rodolfo Teófilo (1890) and *O Sertões* by Cuclides da Cunha (1903). These images, particularly the misery of drought migrants, reoccur in Northeastern regionalist novels of the 1930s, including *O Quinze* by Rachel de Queiroz (1930) and *Vidas secas* by Ramos Graciliano (1938). These and other artistic works of the Northeastern regionalist movement of the 1930s homogenize the region through shared images that emphasize wretchedness, poverty, and inequality, which are reinforced by the harsh realities of drought.⁴²

Northeast Brazilian Theatre, which emerged in the 1940s, draws on the cementing regional identity of the 1930s, performing regionalist imaginaries and creating a theatre for *o povo* (the masses) that confronts the power of the wealthy ruling class.⁴³ The founding of the Student Theatre of Pernambuco (Teatro do Estudante de Pernambuco, TEP) in 1946 by Pernambucanos Ariano Suassuna and Hermilo Borba Filho marks the beginning of the Northeast Brazilian Theatre movement, a movement that centered the masses of Northeast Brazil, who were typically relegated to the margins of society.⁴⁴ Ariano Suassuna is considered one of the most emblematic playwrights of Northeastern regionalist theatre, in large part because his plays were performed in São Paulo, the booming Southern Brazilian city where Brazilian theatre was going through a process of

⁴¹ Eduardo de Almeida Navarro, *Dicionário de tupi antigo: a língua indígena clássica do Brasil* (São Paulo: Global, 2013).

⁴² Durval Muniz de Albuquerque Jr., *A Invenção do Nordeste e Outros Artes*.

⁴³ While the Northeast Brazilian theatre movement emerged in the 1940s, folk performance forms, including storytelling, have a much longer history.

⁴⁴ Francisco Geraldo de Magela Lima Filho, ‘Gênese popular do teatro nordestino’, *Contraponto*, 8, 1 (January – June 2019), pp. 51-72.

modernization during the 1950s.⁴⁵ Through their works, Ariano Suassuna and Hermilo Borba Filho denounce inequality faced by the impoverished dwellers of the Northeastern sertão, drawing on regionalist literature from the 1930s, as well as Iberian playwrights, including those of the Siglo del Oro (16th and 17th century Spain) and Federico García Lorca of the 20th century.⁴⁶ Although they invoke familiar Northeastern images of banditry, poverty, and suffering from drought, Ariano Suassuna, Hermilo Borba Filho, and other their contemporaries decry the misery intimately tied to Northeastern imaginaries, elevating, rather, the sense of *saudade* (intimate nostalgia) that intermingles with the hardship of life in the sertão.⁴⁷ Ariano Suassuna championed this sense of nostalgia as a founder of the Armorial Movement in the 1970s, in which performance artists, musicians, and visual artists incorporated typical Northeastern instruments, rhythms, folk elements, and puppet theatre to center the Northeastern identity of the masses and critique the bourgeoisie.⁴⁸ Hermilo Borba Filho similarly continued to sustain a regionalist and socially critical focus in his work at the Teatro Popular do Nordeste (TPN).⁴⁹ The plays written and performed by Hermilo Borba Filho and Ariano Suassuna explore regionalist themes in the Caatinga and rural towns that dotted the sertão, making visible the quotidian struggles of rural dwellers through performances on stages both in the Brazilian Northeast and South. By engaging with the past and present pain of rural dwellers in the Cearense sertão, as well as the possibility of prosperity, Pavilhão da Magnólia and the creators of *The Drought Migrant* contribute to contemporary Northeastern regionalist performance arts.⁵⁰

⁴⁵ João Dantas Filho, 'A dramaturgia regionalista nordestina', *Discursividades*, 2, 1 (March 2018), pp. 28-48.

⁴⁶ João Dantas Filho, 'A dramaturgia regionalista nordestina'.

⁴⁷ Durval Muniz de Albuquerque Jr., *A Invenção do Nordeste e Outros Artes*; João Dantas Filho.

⁴⁸ Candance Slater, 'Folk Tradition and the Artist: The Northeastern Brazilian "Movimento Armorial"', *Luso-Brazilian Review*, 16, 2 (Winter 1979), pp. 160-190.

⁴⁹ Francisco Geraldo de Magela Lima Filho, p. 63.

⁵⁰ Additional artist from Ceará can be located on the Cearense Cultural Map (<https://mapacultural.secult.ce.gov.br/>). Notably, Cearense dramaturg, folklorist, poet, sociologist, and activist Oswald Barroso (1947 – 2024) actively researched and contributed to Northeastern culture and identity throughout his career. In 'A dramaturgia regionalista

Interweaving scenes and dialogue from *O Quinze*, *Water and Drought Dramaturgies* carries out processes of “reactivation”⁵¹—that is, the re-doing of past attitudes, behaviors, and lived experiences in the present—based on historic, climate, and field-based research. Pavilhão da Magnólia is a Fortaleza-based theatre group and was founded in 2005. To devise the performance piece, the actors drew on the archive and the repertoire, the physical and ephemeral, respectively, through which knowledge is stored, reproduced, and changed.⁵² Traces from the archive include the novel *O Quinze*, animal bones they collected during visits to the sertão, data on climate patterns in Ceará and on the 2012-2018 drought through their work with climate scientist Alexandre Costa, regionalist paintings, and newspaper archives. For example, text from *O Quinze* is incorporated throughout the performance, while puppetry is used to embody an emblematic moment in *O Quinze* when the main character, Chico Bento, kills what he believed to be an abandoned goat in order to feed his family. Pavilhão da Magnólia also directly incorporates the archive using the animal bones that the troupe collected during a field excursion through the sertão. Yet, as one of the actors of the company explained, she and her colleagues wanted to incorporate the bones into the production without perpetuating clichés associated with bones and the sertão (Silvianne Lima, personal correspondence, November 27, 2020). In the performance, the group accomplishes the reactivation of associations of animal bones with death and dying in the drought-ridden sertão without relying on clichés by incorporating the physical traces into a scene in which the bones

nordestina’, João Dantas Filho provides the following list of other dramaturgs from Northeast Brazil: Alarico Corrêa Neto, Carmélio Reinaldo, Fernando Teixeira, Geraldo Jorge, Ednaldo do Egipto, Marcus Vinícius, Elpidio Navarro, Bráulio Tavares, Luiz Felipe Botelho, Gilsimar Gonsalves, Marcelo Costa, Oswald Barroso, Ricardo Guilherme, Walden Luiz, B. de Paiva, Emmanuel Nogueira, Rafael Barbosa, Rafael Lins, Newton Moreno, Gil Vicente Tavares, João Falcão, Aldo Leite, João Denys, Cristovam Tadeu, Waldemar José Solha.

⁵¹ Emily Sahakian, ‘LénaBlou and Gilbert Laumord: reactivating history through contemporary Caribbean performance’ in Jeffrey M. Leichman and Karine Bénac-Giroux (eds.), *Colonialism and slavery in performance: Theatre and the eighteenth-century French Caribbean* (Liverpool: Liverpool University Press, 2021), pp. 326-348, p. 346.

⁵² Diana Taylor, *The Archive and the Repertoire*, p. 13.

appear to dance under the craziness of strobe lights and club music. *Water and Drought Dramaturgies* incorporates the archive, including *O Quinze* and animal bones, to reactive regional understandings and memories from the Northeast.

(Re)activating the repertoire of the sertão and reenacting the experiences of drought migrants was more challenging for Pavilhão da Magnólia. This is, in part, because the actors were from the urban area of Fortaleza and did not grow up listening to stories by their parents and grandparents about the hardships of drought in the sertão nor experiencing these challenges personally (Silvianne Lima, personal correspondence, November 27, 2020). However, personal experience, including the childhood of several troupe members spent in the impoverished outskirts of Fortaleza, provided an embodied sense of inequitable access to safety and adequate food and water that parallels inequities in the rural area. Drawing on this lived experience and the recognition that their current socioeconomic status and presence in the Cearense artistic scene afforded them greater visibility than relatives and friends, the crew of Pavilhão da Magnólia sought to express the experiences of rural sertanejos without erasing the voices of these individuals. The company fostered embodied understanding of the sertão during visits to the interior of the state and through experimentation with bonecos in collaborative work with Chico Oliveira (the co-director of *The Drought Migrant*). Walking along the dried dirt roads under the midday sertanejo sun provided the company with a sense of the journeys carried out by rural dwellers in times of drought. At the same time, with the help of Chico, who had been trained to make and perform with bonecos by an elder boneco master, the members of Pavilhão da Magnólia were able to access embodied memory from the rural interior. While not referenced by the actors, the Jaguaribe River acts as part of both the archive and the repertoire, as the waters that flow through it leave physical traces yet become part of the ephemeral repertoire in periods of drought. Regionalist imaginaries

of the sertão and Northeast Brazilian Theatre's tradition of social criticism flow through *Water and Drought Dramaturgies* via Pavilhão da Magnólia's cultivation of the archive and repertoire of the Cearense sertão.

Unlike Pavilhão da Magnólia, the creators of *The Drought Migrant* draw on more intimate relations with the repertoire, combining their own lived experience living in the Jaguaribe Valley with the embodied memory of their ancestors to create *The Drought Migrant*. Débora and Chico wanted to create a film together that used traditional performance forms from their families—storytelling and puppetry—and that blended reality with fantasy to explore the suffering that generations of impoverished sertanejo farmers have faced during periods of drought. The two carried out multiple roles on and off screen: in addition to writing, co-directing, and producing the film, Débora embodied the roles of the narrator, the skeleton drought migrant, and an ambiguous figure who aids the Jaguaribe River as the fisherman, interpreted by Chico, pulls the skeleton drought migrant's figure out of the flowing waters. Chico, in addition to playing the role of the fisherman, embodied the journey of the retirante in his work with puppetry in the mixed live-action, animation film. *The Drought Migrant* performs the Jaguaribe River's flow and the multifaceted relationship between water and people in the sertão. Reactivating the cultural memory of their relatives and their lived experience during drought cycles in the sertão, the crew developed a piece that, like their Northeast Brazilian Theatre predecessors, foregrounds the struggles, sorrow, and vitality of impoverished masses of the sertão.

2.3 The Presence and Politics of the Jaguaribe River

In order to understand how *Water and Drought Dramaturgies* and *The Drought Migrant* contribute to the landscape of Cearense theatre, it is important to first consider the histories and

political realities along the Jaguaribe River. The force of the intermittent flow of the Jaguaribe River situates *Water and Drought Dramaturgies* and *The Drought Migrant* within Ceará, Northeast Brazil. The word “Jaguaribe” is an indigenous term from the Tupi language and means “river of the jaguar (*Panthera onca*).”⁵³ During the colonization of the hinterlands of Ceará, which occurred between 1680 and 1720, Indigenous populations along the banks of the Jaguaribe River were expelled, enslaved, exterminated, or forced into organized villages, as disputes over land for cattle raising began among colonizers.⁵⁴ The Jaguaribe River was fundamental to the colonial project, its margins acting as river roads that guided the movement of cattle and the expansion of economic and political power.⁵⁵ Given the river’s importance, discussions of how to perennialize it, including the possible transposition of water from the São Francisco River,⁵⁶ began in the 19th century during the Brazilian Empire.⁵⁷ Yet hydraulic infrastructure projects did not begin until the First Republic, in the late 19th and early 20th century. At that time, engineers working for the federal government devised various dams along the Jaguaribe River to perennialize sections of it, actions that impacted the flora and fauna within and along the banks of the Jaguaribe River and that, in the lower section closest to the Atlantic Ocean called Baixo Jaguaribe, caused the water to become unpotable due to increased salinization.⁵⁸

⁵³ Gabriel Pereira de Oliveira and Eurípedes Antonio Funes, p. 57.

⁵⁴ Amanda Teixeira, ‘O processo inquisitorial de Manuel Frago de Albuquerque e a circulação de pessoas e notícias nos sertões coloniais’, *Mneme - Revista De Humanidades*, 24, 47 (August-September 2023), pp. 1-19.

⁵⁵ Gabriel Pereira de Oliveira and Eurípedes Antonio Funes, p. 60. For a more detailed account of the importance of the Jaguaribe River in terms of the politics of colonization and the control of water in the region, please see Gabriel Pereira de Oliveira and Eurípedes Antonio Funes.

⁵⁶ The São Francisco River is the fourth-largest river in South America and one of the only perennial streams in the Brazilian semi-arid region. Construction work toward the transposition of the São Francisco River to Ceará through canal systems eventually began in 2007, during Lula’s presidential mandate. While the project has yet to be completed as of March 2024, water first arrived in Ceará in February 2024 (Cearense Secretariat of Water Resources, [https://www.ceara.gov.br/2024/02/16/aguas-do-sao-francisco-sao-liberadas-para-o-ceara-e-seguem-ate-o-acude-castanho/#:~:text=As%20%C3%A1guas%20da%20Transposi%C3%A7%C3%A3o%20do,Cintur%C3%A3o%20das%20%C3%81guas%20\(CAC\)](https://www.ceara.gov.br/2024/02/16/aguas-do-sao-francisco-sao-liberadas-para-o-ceara-e-seguem-ate-o-acude-castanho/#:~:text=As%20%C3%A1guas%20da%20Transposi%C3%A7%C3%A3o%20do,Cintur%C3%A3o%20das%20%C3%81guas%20(CAC),)), accessed 4 March 2024).

⁵⁷ Gabriel Pereira de Oliveira and Eurípedes Antonio Funes, p. 64.

⁵⁸ Kamillo Karol Ribeiro e Silva, *Um rio entre diversas temporalidades: o Jaguaribe a partir da construção do açude Orós (1958-1964)*, Doctoral dissertation (2020), Fortaleza: PPGH-UFC.

While the construction of small reservoirs impacted the flow and quality of water along the Jaguaribe, the most significant hydraulic infrastructure projects to impact the way water traverses the Jaguaribe Valley were the construction of three large-scale reservoirs by the National Department of Works Against Drought (DNOCS):⁵⁹ the Orós Reservoir (constructed between 1921 and 1960), the Banabuiú Reservoir (constructed between 1958 and 1966), and the Castanhão Reservoir (constructed between 1995 and 2002). The Castanhão is the largest multi-use reservoir in Latin America, with a capacity of 6.7 billion m³. It was constructed to control flooding in the Jaguaribe Valley and to guarantee water supply for multiple uses in the Jaguaribe Valley, including large-scale irrigation, and to guarantee the water supply of the metropolitan area of Fortaleza, the capital of Ceará.⁶⁰ Fortaleza is a major metropolitan area and home to the state's key government agencies and the majority of the state's population. The 2012-2018 drought, which is considered the worst in recent history, severely increased the stress on limited water resources, exacerbating conflicts related to the tradeoffs of provisioning scarce water resources for industry, irrigation, and human consumption across the rural sertão and the capital on the coast.⁶¹

Brazil has attempted to improve water management by transferring federal-level decision-making to the river basin level, yet, as I observed during fieldwork in the Jaguaribe Valley in 2018, river basin committee members often feel resentment toward the State, as Fortaleza's water needs are prioritized, and rural areas are left without reliable water supplies. At the same time, disparities in water access among users serving on a specific river basin committee result in intra-committee conflicts. During my summer 2018 fieldwork, I listened to animated discussions related to the

⁵⁹ The name of IFOCS was changed to DNOCS in 1945 (Brazilian Decree-Law 8.486, December 28, 1945).

⁶⁰ Departamento Nacional de Obras Contra as Secas, <https://www.gov.br/dnocs/pt-br/assuntos/noticias/noticia-site-antigo-3474>, accessed 4 March 2024.

⁶¹ Jose A. Marengo, Roger Rodrigues Torres, and Lincoln Muniz Alves, 'Drought in Northeast Brazil—past, present, and future', *Theoretical and Applied Climatology* 129 (2017), pp. 1189-1200.

water that flows from the Jaguaribe Valley to Fortaleza, discussions that went back and forth between the innate struggle for survival in the harsh semi-arid environment and the need to learn to live in harmony with the region. Within this contentious context, *Water and Drought Dramaturgies* and *The Drought Migrant* embody historical and contemporary water struggles in the region, locating universalizing imaginaries of Northeast Brazil along the shores of the Jaguaribe River.

2.4 Contesting Present-Day Water Injustices in *Water and Drought Dramaturgies*

Water and Drought Dramaturgies confronts the injustices felt by current residents of the Jaguaribe Valley by performing contemporary water politics, blending and juxtaposing images from 20th century Northeastern regionalist movements and 21st century exploitative practices of large agribusiness. One scene begins in darkness with a long drag of an accordion, followed by a mournful call, “Ô! Meu boi...” (“Oh! My ox...”). The accordion summons the Northeastern regionalist melodies of accordionist Luiz Gonzaga from the 1940s and 1950s,⁶² while the lament recalls the familiar image of emaciated livestock abandoned during periods of drought across the sertão.⁶³ The spotlight slowly reveals that the laments come from a man—embodying past and present impoverished rural dwellers—lying on his back on the light brown floor, reminiscent of the sertão’s terra rachada. Eventually, the man’s woeful song is replaced with what seems like a dial-tone, as the spotlight illuminates the man’s bare feet.

⁶² Michael B. Silvers, *Voice of Drought: The Politics of Music and Environment in Northeastern* (Urbana, Chicago and Springfield: University of Illinois Press, 2018), p. 59.

⁶³ The ox also forms part of the folklore across Northeast Brazil, particularly in the festival of Bumba Meu Boi, which depicts the death and resurrection of an ox (Maria Laura Viveiros de Castro Cavalcanti, ‘Tempo e Narrativa nos Folguedos do Boi’, *Revista Pós Ciências Sociais*, 3, 6 (July – December 2006), pp. 61-88). In an interview in May 2019, Henrique Oliveira explained to me that the tradition is particularly important in the sertão, including in his home city of Quixeré.

The scene transitions as the spotlight turns off, and the rustling of paper is heard over the dial tone. Soon, three people enter the scene, their smiles and business attire starkly contrasting the simple clothing of the man still lying on the ground, his accordion expanding and compressing in silence. With more smiles and firm handshakes, the three businesspeople leave the scene, the man on the ground an invisible, silent witness to the deal they have made. While the details of the three's dealings are left ambiguous, in a later scene, the audience becomes privy to the phone conversation of one of the three. In that scene, the businessman discusses the appropriation of the lands held by small farmers in order to expand the Irrigation Perimeter of Russas, located in the Jaguaribe Valley, to the benefit of large-scale irrigation projects. The juxtaposition of the silent farmer lamenting his ox and the giddy businesspeople who almost step on the man recreates past and contemporary power relations between rural farmers and the wealthy elite. The realities of the small farmers are invisible to the wealthy urban class, who continue to reap benefit from the rural regions of Ceará.⁶⁴

In a subsequent scene, the politics of contemporary bulk water allocation are confronted, as a woman hastily works to fill a row of various glasses with water from a large, glass jug (Fig. 2.1). In the scene, the woman crawls back and forth between the glasses, filling the ones left empty as she goes. Once the jar is empty, she must take water already allocated to a particular glass in order to fill the ones that remain empty. The work is not over, though, as she then seems to make the effort to equalize the water across the different vessels. As she pours water from one glass to

⁶⁴ For more detailed discussion on Brazil's decentralized water management system, including the processes by which river basin committees deliberate the allocation of water from state-monitored reservoirs, see, for example: Rebecca Neara Abers and Margaret E. Keck, 'Muddy waters: Decentralization, coordination and power struggle in the Brazilian water management reform', *International Journal for Urban and Regional Research*, 30, 3 (2006), pp. 601-622; Andrew Reid Bell, Nathan Lee Engle, Maria Carmen Lemos, 'How does Diversity Matter? The Case of Brazilian River Basin Councils', *Ecology and Society*, 16, 1 (March 2011), pp. 1-19; Maria Carmen Lemos and João Lúcio Farias de Oliveira, 'Water reform across the state/society divide: The case of Ceará, Brazil', *International Journal of Water Resources Development*, 21, 1 (2007), pp.133-147; Maria Carmen Lemos, Bruno Peregrina Puga, Rosa Maria Formiga-Johnsson and Cydney Kate Seigerman, 'Building on adaptive capacity to extreme events in Brazil'.

another, precious drops of water fall to the ground. She pays them no mind. Her job is to distribute the water, and the water lost in the process is part of the process.



Figure 2.1 Imperfect water redistribution.

Silvianne Lima frantically redistributes water among various glass containers during the performance (Source: Screenshot of the recording of the performance *Water and Drought Dramaturgies*).

This loss of water mirrors the water lost to evaporation or to the inefficiency of equipment during transfers from reservoirs in the interior of Ceará to urban areas, like Fortaleza, through open canal systems. Despite this parallel, the woman's intention to adequately distribute water across the different containers contrasts the realities of water distribution in the state. In the woman's frenzy, the businesspeople's intentions to acquire land for the Russas Irrigation Project from an earlier scene are made audible. The distinction between the two positions is solidified in the final image of the scene, which reveals that the woman has placed all of the glasses on a tray, as if to serve water to the businessman and his associates, while the businesspeople continue their discussion regarding the acquisition of land to expand the large-scale irrigation projects. This scene is juxtaposed by others in *Water and Drought Dramaturgies* that recreate excerpts from *O Quinze*,

highlighting the continuation and evolution of unequal power relations that help guarantee water for some and not for others in the Cearense sertão.⁶⁵

2.4 Frailty, Force, and Faith along the Jaguaribe River in *The Drought Migrant*

Whereas *Water and Drought Dramaturgies* engages with regionalist imagery from *O Quinze* to contest contemporary water politics that determine water flows and access along the Jaguaribe River, *The Drought Migrant* draws more so on the creators' desire to perform their own embodied memory of the Jaguaribe River. In an interview, Débora recounted the contrast between her childhood, as she played along the vibrant shores of the Jaguaribe and listened to her mother tell stories of the hardships of drought, and her adulthood, as she watched the emergence of the legendary dried riverbed during the most recent drought from 2012 to 2018. In *The Drought Migrant*, Débora translates the river's transitions of her own experience to that of young girl, the drought migrant after whom the film is named. In the film, the girl, portrayed in puppet form, is abandoned by her father as the two traverse the drought-ridden landscape of Ceará. The girl soon perishes of thirst and hunger under the piercing sertanejo sun, her body left to the vultures on the terra rachada of the dried out Jaguaribe River's riverbed. Her skeleton is eventually buried under the currents of the Jaguaribe River, reinvigorated during a period of rainfall between droughts. The waters are full of life and hope when a fisherman encounters the drought migrant generations later. The Jaguaribe River's transition from dryness to vitality in the film mirrors its transition from vitality to dryness in Débora's life. Débora's embodied nostalgia flows through the river in *The Drought Migrant*, echoing the nostalgia that underpinned the Northeastern regionalist movement

⁶⁵ For example, in the opening scene, direct quotes from Rachel de Queiroz's *O Quinze* are recited between the calling out of the years from 1915—the year in which the novel is set—until 2019, the year after the performance takes place. In a later scene, puppetry is used to embody the moment in *O Quinze* when the main character, Chico Bento, kills what he believed to be an abandoned goat.

promoted by sociologist Gilberto Freyre in the early 20th century and further shaped by regionalist literature and music of the mid 20th century,⁶⁶ as well as by Northeast Brazilian Theatre.⁶⁷

The Jaguaribe River's current is embodied in the short film through lighting effects, the wispy playfulness of cloth, the rhythmic rocking of the fisherman's boat, and crystalized tears. After recounting the sorrowful story of the girl's death, the narrator explains that the girl's bones were eventually covered by the current of the Jaguaribe River. The account is accompanied by the image of a skeleton puppet and its human companion submerged underwater, the effect created by a delicate cloth illuminated with blues and teals that moves carefree as if it were water itself. In contrast to the depths of the Jaguaribe River, water is represented above the surface by the rocking of the fisherman and his boat. Both steadily swing back and forth, as the fisherman travels down the river on his expedition. In a later scene, an unlikely water source appears as the fisherman sleeps: the sleeping man sheds a single tear, which appears as a brilliant crystal resting on the man's face. According to the narrator, the presence of the tear produces a great thirst in the skeleton woman, who had been pulled up from the depths of the Jaguaribe River by the fisherman's net. The skeleton drought migrant, in this scene played by Débora, places her lips onto the tear, quenching generations of thirst by the single tear. She drinks the tear that has become like an endlessly flowing river, able to satiate her insatiable thirst. Akin to the fisherman, whose tears indicate a state of hydration, the skeleton drought migrant no longer suffers from the thirst that accompanied her in death.

In addition to embodying water itself, the teardrop that escapes from the fisherman's eye during his slumber activates locally situated spiritual meanings of water. Before the single

⁶⁶ Durval Muniz de Albuquerque Jr., *A Invenção do Nordeste e Outros Artes*.

⁶⁷ Candace Slater, 'Folk Tradition and the Artist: The Northeastern Brazilian "Movimento Armorial"'.

rejuvenating tear is shed, the fisherman cries from exhaustion and is calmed by religious and spiritual figures known across Northeast Brazil: the Afro-Brazilian orixá Oxúm (the Water Saintress), the Catholic Our Lady of Conception, and the local saint Padre Cícero. The evocation of the three figures brings attention to the religious syncretism characteristic to Northeast Brazil and Brazil, more broadly. The fisherman's tears dry, and in a state of calm, he disentangles the skeleton of the drought migrant and goes to sleep. While the first tears shed by the fisherman are out of distress, the tear that restores the skeleton drought migrant is one of regeneration that evokes the tears of Oxúm—goddess of beauty, self-awareness, fresh water, and waterfalls. Oxúm's tears express both sorrow and joy,⁶⁸ just as the fisherman's tear, which the narrator speculates stems from anxiety or sadness, may be in mourning of the death of the young drought migrant and countless others who suffered similar a fate. The reassurance provided by the image of Santa das Águas, Nossa Senhora Aparecida, or Padim Ciço and the regenerative spirit in the fisherman's tear emphasize the depth of water's spirituality, while underscoring the history of suffering by impoverished rural dwellers along the Jaguaribe River. Invoking water's fluid and spiritual natures along the Jaguaribe River, *The Drought Migrant* embodies Northeast Brazilian regionalist imaginaries and situates them within the lived experience of the film's creators.

2.5 Performing Water's Absence

In the earlier parts of this article, I have focused on how water and its myriad meanings are performed in *Water and Drought Dramaturgies* and *The Drought Migrant*. Yet, as “a child of drought,”⁶⁹ Northeast Brazil's imaginary is defined often more so by the absence of water than by

⁶⁸ Florence Dravet, ‘Para uma Crítica à Pieguice: imagens e imaginário das lágrimas’, XXVIII Encontro Anual da Compós, Pontifícia Universidade Católica do Rio Grande do Sul, Porto Alegre (11 to 14 June 2019), pp. 1-22.

⁶⁹ Durval Muniz de Albuquerque Jr, ‘Weaving Tradition’, p. 44.

its presence. In their performance pieces, Pavilhão da Magnólia and Débora and Chico perform this key facet of Northeast Brazil's identity by illustrating water's limited nature. To begin the performance of *Water and Drought Dramaturgies*, the members of Pavilhão da Magnólia share water stored in *moringas de barro* (small clay jugs typical of the rural sertão) with the audience members, who, waiting to enter the main theatre, congregate in the antechamber. With care, many of the audience members accept the offering. The *moringas* are returned to their keepers, along with smiles of gratitude and quenched thirst. But the water held in the *moringas* is not infinite. As background music crescendos, the actors bring the *moringas* to their lips. They freeze in the act, as if to cherish the final drops of water that the *moringas* can offer. Empty and dry, the *moringas* are brought overhead, the actors with faces of forlornness, anger, despair, and perhaps hope. A moment of pause fills in the antechamber, as the cheerful giddiness of shared water and smiles has been replaced by the silent stares of the audience members as they await in the stillness and uncertainty created by the actors and their empty *moringas* (Fig. 2.2a)

Water's notorious absence in the sertão is performed in a similar way in *The Drought Migrant*. The narrator's telling of the drought migrant's futile search for water and food in the drought-ridden landscape is accompanied on screen by a young girl holding an empty *moringa* to her lips, the last drops of water caressing her lips, as she holds the empty clay vessel in vain above her head (Fig. 2.2b). However, whereas the *moringas* in *Water and Drought Dramaturgies* are emptied through acts of generosity and water sharing, the young girl's dried *moringa* represents the abandonment by her father and the absence of the help of others. The actors in *Water and Drought Dramaturgies* perform a collective act of care and then run out of water, experiencing scarcity in community. They subsequently invite the community with whom they shared their limited water to enter a shared drought universe. For the drought migrant, on the other hand, the

last drops of water from her *moringa* represent the last of her vitality. As the final drop of water falls into the girl's mouth, the narrator recounts that the drought migrant soon perishes alone of thirst and hunger under the piercing sertanejo sun. In both pieces, water's scarcity across the Northeastern sertão in times of droughts and the longing this absence provokes are performed by the last drops of drinking water stored in *moringas*. Yet, the emptying of the *moringas* builds community in *Water and Drought Dramaturgies*, while it evokes loneliness in death in *The Drought Migrant*.

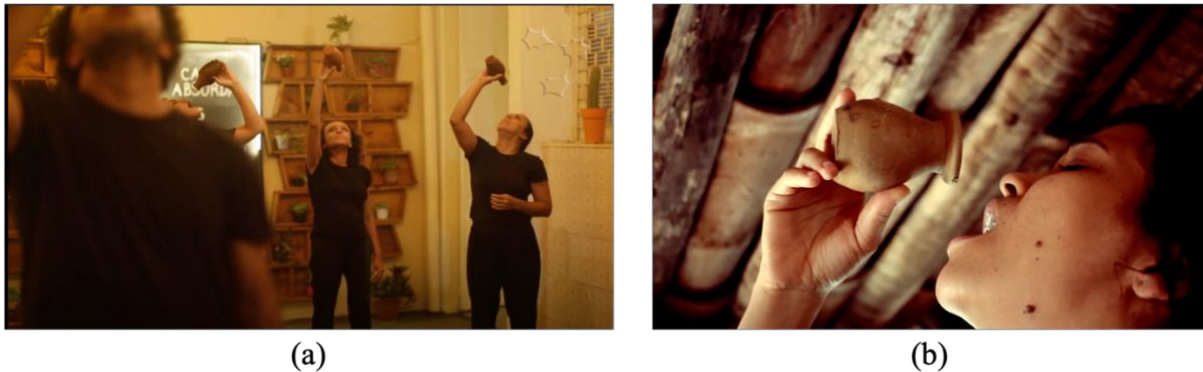


Figure 2.2 Performing water's absence with *moringas* of water.

(a) Members of Pavilhão da Magnólia pause with their empty *moringas* over their heads in the opening scene of *Water and Drought Dramaturgies* (Source: screenshot of the recorded performance of *Water and Drought Dramaturgies*); (b) A girl drinks the last drop of water in her *moringa* in *The Drought Migrant* (Source: screenshot of film).

The absence of water is also embodied through representations of *terra rachada* in the two performances. In *Water and Drought Dramaturgies*, the dried, cracked riverbed of the Jaguaribe River is recreated by the actors and the empty *moringas* they held over their head in expectation. The moment of pause created by the actors is broken as a *moringa* falls to the floor and cracks, the actor abandoning the empty clay jug. The other actors follow suit, and soon a cacophony of breaking clay competes with the singing that persists in the background. Picking up the shards of the once sturdy clay vessels, the actors smash these pieces into the floor. The brokenness

multiplies. As the frenzy continues, the actors begin to arrange the pieces of shattered *morginas* to form the *terra rachada* of a drought-stricken riverbed (Fig 2.3). The audience members traverse the path of broken earth in order to reach the main theatre, the clay cracking under their feet. The brown tones of the *terra rachada* dominate the remainder of the performance, an omnipresent reminder of water's absence in the present of drought in Northeast Brazil. Unlike in *Water and Drought Dramaturgies*, *terra rachada* is referenced by name by the narrator in *The Drought Migrant*. In this scene, the cracked riverbed of the Jaguaribe River is depicted by the wooden floorboards of the house where the film was made. The puppet of the drought migrant is thrown to the floor. As the girl lies supine with her small bundle of possessions beside her, the shadows of *carcarás*, a bird of prey endemic to the *sertão*, dance across her body. The narrator describes how the birds devour the girl's *carne* (flesh), leaving only her bones, bare and dried, on the *terra rachada* that makes up the riverbed of the Jaguaribe River. In this way, *The Drought Migrant* makes a direct reference to the *terra rachada* and dried *sertanejo* landscape that saturate imaginaries of Northeast Brazil. In both performance pieces, the *terra rachada* of the Jaguaribe River and the experience of the last drops of water stored in clay *morginas* portray water's absence and the yearning this absence creates.



Figure 2.3 The performance of *terra rachada* through broken clay *morginas* in *Water and Drought Dramaturgies*. (Source: A screenshot of the recorded performance of *Water and Drought Dramaturgies*).

2.6 The Flow of Water and Collaborations from the Jaguaribe Valley to Fortaleza through Performance

2.6.1 Fluid Collaborations between Fortaleza and the Jaguaribe Valley

Pavilhão da Magnólia, Chico, and Débora are not only related by their engagement with Northeast Brazilian imaginaries to perform watery relations along the Jaguaribe River. Rather, the physical flow of water through the Jaguaribe Valley, collaborations, and the Cearense government's digital Cultural Map also connect them. The Jaguaribe River flows through both works yet across different temporalities—it is the perennialized river of the present in *Water and Drought Dramaturgies* and an ephemeral stream without human regulation in *The Drought Migrant*. At the same time, outside of the performance space—particularly during the most intense years of the 2012-2018 drought—the water flowing through the taps of Casa Absurda and the homes of the artists of Pavilhão da Magnólia and of the members of the audience of *Water and Drought Dramaturgies* in Fortaleza had been diverted from the Jaguaribe River, which supplies water to Chico and Débora in the Jaguaribe Valley. The fluid connections between the groups converged during the development of *Water and Drought Dramaturgies*, as Pavilhão da Magnólia expanded their artistic repertoire through the experimentation with bonecos in-person with Chico in the Jaguaribe Valley. At the same time, the artists are connected virtually, as they form part of the network of artists located on the Cearense Cultural Map.

My initial engagement with both groups emerged through the active network of performance artists in Ceará that they form part of and that is made visible by the Cearense Cultural Map. I initially “found” Chico as I perused the Cultural Map to locate local performance artists in the Jaguaribe Valley with whom I could collaborate for performance-based fieldwork. Yet my first

attempt to communicate with him and his theatre group, Troupe Motim failed as the Facebook message I sent Chico was left unanswered. Around the same time, after a Google search led me to the project “Dramaturgias da Água e da Seca” and the Creation Laboratories, I contacted the director of the Laboratories through Facebook and received no response.

I eventually succeeded in meeting the director of the Laboratories after becoming physically intertwined in the network of Cearense performance artists by attending free directing workshop at O Porto Iracema das Artes Art School in May 2019. Through the connections I made, I was able to visit Chico in Quixeré and Pavilhão da Magnólia in their performance space in Fortaleza later that month. Chico brought me to the Jaguaribe River and told me about the injustices that his family, his neighbors, and he felt as they watched the flow of the river dwindle due to drought and water allocation decisions. In Fortaleza, members of Pavilhão da Magnólia expressed similar distress over the inequitable water access they knew existed among rural communities in the Jaguaribe Valley, large irrigators in the region, and the industries and people in Fortaleza. During the lockdown that characterized the early months of the Covid-19 pandemic, I remained in contact with these artists virtually, while I remained in Athens, Georgia and they stayed in their homes in Fortaleza and the Jaguaribe Valley. The pandemic made the inequities we had discussed even more pronounced, as the lack of quality water compounded with limited access to food and healthcare in rural communities. The continued injustice in the region became an impetus for the production of *The Drought Migrant* in 2020 and, over the past couple of years, has also helped shape Pavilhão da Magnólia’s performance piece, *A Força da Água (The Force of Water)*, the second part of the project “Dramaturgias da Água e da Seca.”

2.6.2 *The Performance of Water Inequities*

While the two groups experience the water of the Jaguaribe River differently, both perform the water-related injustices experienced along the river in their productions. In *Water and Drought Dramaturgies*, Pavilhão da Magnólia interweaves the suffering of impoverished rural dwellers during the 1915 drought with contemporary water inequities, juxtaposing and mingling text and moments from the novel *O Quinze* with scenes that represent present-day water negotiations to benefit large agricultural in the Jaguaribe Valley. Across these scenes, the distress of Chico Bento, a drought migrant from *O Quinze*, parallels the silenced suffering of the nameless man who embodies the experience of present-day rural dwellers, whose needs become invisible in decisions that determine water flows along the Jaguaribe River. The skeleton drought migrant in *The Drought Migrant* also symbolizes the woeful stories of countless rural dwellers, who, lacking food and water, were forced to traverse the Cearense sertão in search of ways to sustain themselves in times of drought. In the film, Débora and Chico draw on their own lived experience and that of their families in the Jaguaribe Valley to perform the distress of drought and the joys of water's abundance experienced by rural dwellers as the current of the Jaguaribe River ebbs and flows.

In *Water and Drought Dramaturgies* and *The Drought Migrant*, the performance of water tells stories of inequitable water access and drought-related suffering, contextualizing Northeast Brazilian imaginaries along the Jaguaribe River. Pavilhão da Magnólia's current work, *The Force of Water*, expands on the themes in *Water and Drought Dramaturgies* by interrogating the politics of water infrastructure, which continue to shape the flows of the Jaguaribe River. Over the past few years, I have contributed to writing grant proposals, have worked as a dramaturg on the production, and have contributed to the script for the performance piece to be debuted in March 2024. Most of my contributions to the project have been virtual. However, an abundance of care

continues to flow through our messages, as we work toward the shared goal of using performance to reveal new insights into the water-related injustices that characterize Ceará today and that form part of the imaginaries of Northeast Brazil.

CHAPTER 3

THE EVALUATION OF EVAPORATION RATES FROM TWO RESERVOIRS USING
FLOATING MINIPANS IN THE SEMI-ARID REGION OF CEARÁ, NORTHEAST
BRAZIL⁷⁰

⁷⁰ Seigerman, C. K., Rasmussen, T. C., Martins, E. S. P. R., Rodrigues, C. F., Almeida da Silva, F., Alexandre, R. B., & Holanda de Oliveira, D. to be submitted to *Journal of Hydrology: Regional Studies*.

3.1 Introduction

Small to large reservoirs are commonly constructed to increase water supply across semi-arid regions, despite the high evapotranspiration rates characteristic to these environments (Liebe et al, 2005). In Ceará, Northeast Brazil, surface water from reservoirs provides 91% of the state's water supply (Araújo et al., 2004). Reservoirs are key adaptation strategies for supplying water for human consumption, animal husbandry, irrigation, and industrial purposes (Seigerman et al., 2024). Yet, water storage in semi-arid regions faces potential evaporate losses of close to 40% of surface water stored (Mady et al., 2020). Given the large impact of evaporation on water supply, greater understanding of evaporate losses from reservoirs in semi-arid regions is essential to improve water management (Martínez-Granados et al., 2011). In this paper, we assess evaporation rates from two municipal-managed reservoirs in the municipality of Quixeramobim, located in the semi-arid region of Ceará.

A major challenge to estimating lake evaporation is the use precise and simple methods that consider the influence of various environmental variables (Majidi et al., 2015; Farias Mesquita et al., 2020). Because direct measurements of evaporation from a free water surface are rare and typically limited to relatively small spatial and temporal scales, a variety of methods have been developed to estimate evaporation using meteorological data, including the Penman equation, the Bowen ratio-energy balance (BREB) equation, the Dalton method, and mass or water balance methods (Jones, 1992). The Penman equation (Penman 1947, 1948) is commonly used in the literature to calculate evaporation from open water bodies, but the measurements of the variables required is challenging for semi-arid regions where data availability and resources are limited (Alazard et al., 2015). The BREB equation is also a standard method for estimating free water surface evaporation, yet it suffers from the same challenges as the Penman equation in data-limited

regions (Majidi et al., 2015, Malek & Bingham, 1993). Mass or water balance methods require fewer measurements than the Penman and BREB equations and are used to calculate open water evaporation as the change in volume of water stored and the difference between inflow and outflow (Pineiro et al., 2019). The Dalton method, which considers evaporation as a function of vapor pressure deficit (VPD) and wind speed, is a common mass-transfer method to estimate free water surface evaporation, as it is relatively simple and accurate (Singh & Xu, 1997). However, given possible errors, mass and water transfer methods are typically not applicable for periods shorter than one month (Finch & Calver, 2008).

Given its relatively simplicity and low cost, pan evaporation (E_p) is a popular method to estimate lake evaporation across different climates worldwide (Anda et al., 2016, Lim et al., 2013). E_p uses standard water-filled tanks to physically measure atmospheric evaporative demand (Stanhill, 2002). Evaporation pans are usually installed on land and used to estimate evaporation from nearby free water surfaces. Across the world, a variety of pans with different geometries, installation methods, and structures that impact measured evaporation results are utilized, including the Class A pan (in North America and Australia), GGI3000 (in Russia), and E601B and D20 pans (in China) (Zuo et al., 2016). To calculate evaporation from nearby free water surfaces, a pan coefficient is determined based on E_p , assumed to be a function of radiation, wind speed, temperature, and humidity (Allen et al., 1998, Lim et al., 2013).

Pan evaporation studies have shown a decrease in E_p over the past decades, and explanations for this trend vary (Micvar et al., 2012, Mozny et al., 2020, Roderick et al., 2002, Zuo et al., 2016). This is, in part, because the relationship between E_p and the evaporation from free water surfaces is not fully understood and can vary based on factors including climate and pan characteristics (Lim et al., 2016). Different pan coefficients are used to estimate evaporation from

lakes depending on the time period (e.g., annual evaporation compared to seasonal evaporation). Without an empirically derived pan coefficient, Class A land pans normally overestimate actual evaporation (Koerselman and Beltman, 1988, Masoner et al., 2008, Sumner and Jacobs, 2005).

Floating pans installed on a body of water can better simulate the physical conditions that control evaporation in free water surfaces compared to land pans. Masoner et al. (2008) found that a floating Class A evaporation pan in a small free water surface better simulated actual physical conditions on the water surface that impact evaporation better than a Class A pan on land. Despite this finding, limited examples of the use of floating evaporation pans exist to date (e.g., Gallego-Elivra et al., 2012, Nejatian et al., 2022). The installation of a floating Class A pan requires resources that may be infeasible to obtain in regions where funding for such studies is limited. A promising solution to this problem is the use of relatively inexpensive floating minipans (Caissie, 2016; Maheu et al., 2014).

The present study developed a method to measure evaporation using floating minipans in order to estimate evaporation from the Cachoeira do Germano and São Miguel Reservoirs, located in the tropical semi-arid region of Quixeramobim, Ceará, Brazil. The methods used by Caissie (2016) and Maheu et al. (2014) to measure river evaporation were adapted to measure evaporation from the two reservoirs. Evaporation loss coefficients based on different climate and experimental-design variables were analyzed using analysis of variance (ANOVA) to determine the predictive value of these variables.

3.2 Study Area

The Banabuiú River Basin (BRB) is located in Ceará, Northeast Brazil (Fig. 3.1). The region experiences a tropical semi-arid climate, with well-defined rainy and dry seasons, low

average annual rainfall (<800 mm) concentrated during the months of February through May, high temperatures (maximums approximately 36°C), high evapotranspiration rates (approximately 2000 mm/year), and large spatial and temporal rainfall variation. The BRB has a drainage area of 19,647 km² (13.4 % of the area of Ceará). The 15 municipalities that make up the BRB are home to a total of 511,633 inhabitants, according to the 2022 Brazilian Census, and 61.5 % of households in the BRB reside in urban areas, while 38.5 % reside in rural areas (IBGE, 2023). Rural households primarily carry out rainfed agriculture. In addition to nineteen state-monitored reservoirs that supply water to urban areas, the BRB has more than 17,000 private and municipal reservoirs, which are primarily used to supply water for household uses and animal husbandry (Seigerman et al., 2024).

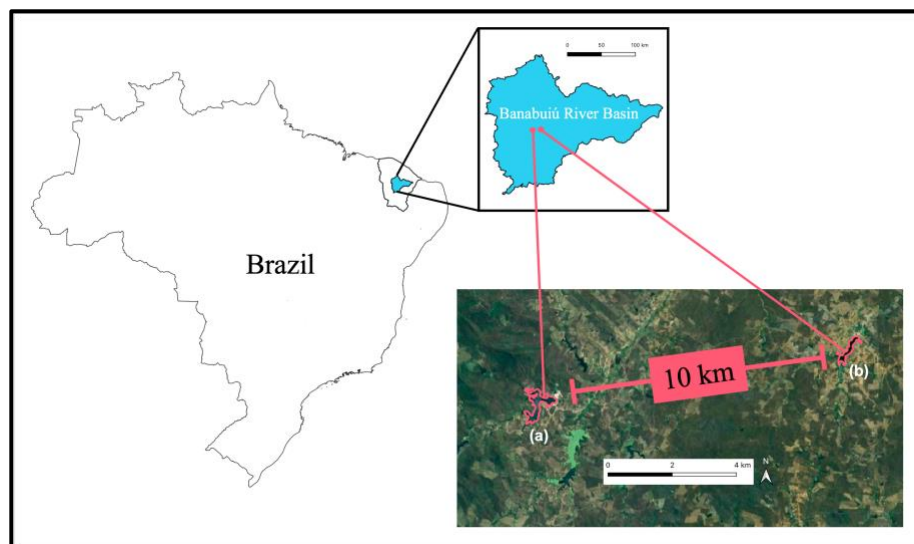


Figure 3.1 Location of the Cachoeira do Germano Reservoir (a) and the São Miguel Reservoir (b) in the Banabuiú River Basin, Ceará, Brazil.

The Cachoeira do Germano and São Miguel Reservoirs were selected for this study given their regional importance and the availability of volume and surface area data from bathymetry studies carried out by the Water Resources Management Company of Ceará (COGERH)

(Table 3.1). The two reservoirs are important municipality-managed reservoirs located in the BRB and in the municipality of Quixeramobim (Fig. 3.1). Because the two reservoirs are managed at the municipal level, COGERH does not monitor water levels, water quality, or water released from the reservoirs. The reservoirs experience different micro-climates. While the São Miguel Reservoir is located in a valley and an urban area, surrounded by the district center of São Miguel, the Cachoeira do Germano Reservoir sits atop the rolling hills that form the Vale do Forquilha (the Forquilha Valley) and is surrounded by the shrubby vegetation characteristic to the Caatinga ecoregion.

Table 3.1 Characteristics of the Cachoeira do Germano and São Miguel Reservoirs in Quixeramobim, Ceará, Brazil. (Data source: COGERH)

Characteristic	Cachoeira do Germano Reservoir	São Miguel Reservoir
Location	5°21'46.3"S, 39°36'22.1"W	5°20'42.1"S, 39°31'04.6"W
Microclimate	Sertão, rural, highlands	Sertão, urban, valley
Surface area (ha)	43.2	19.1
Maximum depth (m)	16.76	8.05
Altitude (m)	294.1	282.9
Year(s) Constructed	2010 to 2012	1958
Uses	Water supply for rural communities, irrigation, federal water truck program, possible water supply to urban center (Pedra Branca)	Water supply for the urban center of the São Miguel district and neighboring rural communities
Management	Owned by municipality, water distribution carried out by local communities	Owned by municipality, water distribution carried out by municipal water authority (SAAE)

The São Miguel Reservoir was constructed in 1958 with federal funding in order to mitigate drought impacts in the region. Today, water stored in the São Miguel Reservoir is used by the Municipal Water Authority (SAAE) to supply water to the urban area of São Miguel and several neighboring rural communities. On the other hand, the Cachoeira do Germano Reservoir was constructed from 2010 to 2012 by the National Department of Works Against Drought

(DNOCS) to perennialize the Forquilha Stream to support small farmers in the Vale do Forquilha, in particular those participating in irrigation projects as part of the Pinga D'água Project (de Oliveira, 2012). Currently, the Cachoeira do Germano Reservoir provides water for household uses, animal husbandry, and irrigation in the Vale do Forquilha and is the main water source for federal water truck (*carro pipa*) operations carried out in the Banabuiú region. In 2021, the Cearense State Government invested 15 million BRL (about 3 million USD) to construct an emergency pipeline connecting the Cachoeira do Germano Reservoir to the urban center of a neighboring municipality, Pedra Branca, whose water system had collapsed.

3.3 Methods and Data

The data collection methods used in this study are summarized in Table 3.2 and described below.

Table 3.2 Data Collection Methods and Sources.

Variable	Method and/or Source
Minipan evaporative loss (g/h)	Physical measurement using minipans (see Section 3.3.1)
Water temperature	At each minipan location: recorded hourly using Hawkeye DepthTrax Handheld Depth Finder
Wind speed	<ul style="list-style-type: none"> • At each minipan location: wind speed recorded hourly using a hand-held anemometer • Offshore on minipan measurement days: recorded hourly by Extech WTH600 wireless weather station • Quixeramobim Weather Station (hourly)^a
Wind direction	Offshore on minipan measurement days: recorded hourly by Extech WTH600 wireless weather station
Relative humidity	<ul style="list-style-type: none"> • At each minipan location: recorded hourly using a hand-held anemometer • Offshore on minipan measurement days: recorded hourly by Extech WTH600 wireless weather station • Quixeramobim Weather Station (hourly average, minimum, and maximum)^a
Air temperature	<ul style="list-style-type: none"> • At each minipan location: recorded hourly using a hand-held anemometer • Offshore on minipan measurement days: recorded hourly by Extech WTH600 wireless weather station • Quixeramobim Weather Station (hourly average, minimum, and maximum)^a
Air pressure	<ul style="list-style-type: none"> • At each minipan location: hourly using a hand-held anemometer • Offshore on minipan measurement days: recorded hourly by Extech WTH600 wireless weather station • Quixeramobim Weather Station (hourly average, minimum, and maximum)^a
Class A Pan evaporative loss (g/day)	Class A pan located at (5°21'11.0"S 39°34'33.8"W) with an altitude of 269.8 m; data source: FUNCEME
Daily cumulative rainfall (mm)	Hydrological Portal of Ceará (http://www.hidro.ce.gov.br/)
Hourly solar radiation (KJ/m ²)	Quixeramobim Weather Station ^a

^a Coordinates: 5°10'22.8"S 39°17'13.2"W; altitude: 227.33 m; from January 1, 2008 to December 31, 2023; data source: INMET (tempo.inmet.gov.br)

3.3.1 Physical evaporation measurements

The dry season was selected as the study period in order to minimize the chance of rain on measurement days and to avoid uncertainty with regard to inflow into the reservoirs. Additionally, in Ceará, water availability is estimated using only evaporation during the dry season (Araújo,

Güntner, Bronstert, 2006; Campos, 2010). The exact measurement dates were based on the availability of equipment and technical support from COGERH. Minipan measurements were carried out between October 31, 2022 and November 3, 2022 at the Cachoeira do Germano Reservoir and between July 21, 2023 and July 24, 2023 at the São Miguel Reservoir.

Floating minipans were used to measure reservoir evaporation (Fig. 3.2). The floating minipans consisted of either a plastic (polycarbonate) or aluminum pan (dimensions: 32.4 x 26.4 x 5.1 cm) inserted into a wooden frame (37 x 31.8 x 5.7 cm). The pans were secured in the frames on two sides with flexible hinges to avoid movement. The wooden frames were painted with a white waterproof sealant in order to minimize solar radiation absorption. Initially, the floating minipans were placed directly into the reservoir and an anchor was used to secure the minipans in place. However, the waves on the reservoir due to wind resulted in splashing, making accurate water loss measurements impossible. As such, rafts were constructed using wooden pallets, soft foam noodles, and empty PET bottles. The minipans were secured to the rafts using nails.



Figure 3.2 Floating minipans: (a) white wooden frames on raft and (b) wooden raft with minipans consisting of a plastic pan (left) and aluminum pan (right).

A total of three rafts, each with two minipans, were placed on the water surface of the reservoir to measure evaporation (Fig. 3.3, Table 3.2). Each raft had one minipan with an aluminum pan and one with a plastic pan. The locations of the rafts were determined based on

water depth measured with a Hawkeye DepthTrax Handheld Depth Finder: one raft was placed near the margin of the reservoir (the shallowest depth), one was placed where the depth of the reservoir was greatest (based on the available bathymetry analyses), and one was placed at a depth between the shallowest and deepest. The rafts were secured in place using an anchor attached to a rope tied around the raft. When possible, the rafts were secured to stationary objects in the reservoir, including a floating fish cage, a staff gauge, and vegetation. The coordinates of each point were recorded in order to place the rafts in the same locations over the three to four days of data collection at each reservoir.

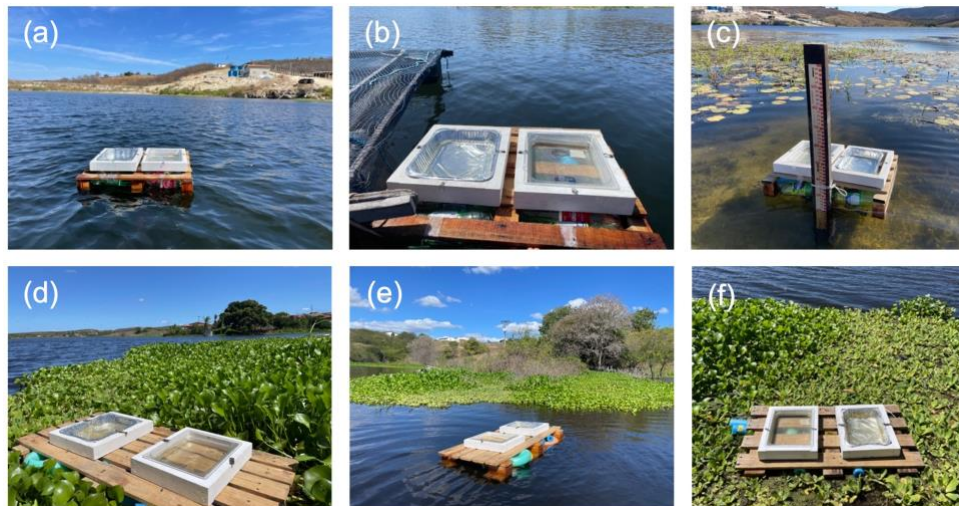


Figure 3.3 Floating minipan placement in the Cachoeira do Germano Reservoir and São Miguel Reservoirs.

Cachoeira do Germano Reservoir: (a) Point A (depth of 16.0 m) secured using an anchor; (b) Point B (depth of 8.6 m) secured to fish cage; and Point C (near shore, depth of 0.1 m) secured to a staff gauge. São Miguel Reservoir: (d) Point D (depth of 10.6 m) secured using floating vegetation; Point E (depth of 3.2 m) secured using an anchor; and Point F (near shore, depth of 0.1 m) secured in floating vegetation.

During the first day of measurements at the Cachoeira do Germano Reservoir, rates were determined in one-hour intervals over a period of six hours by measuring mass losses from the water-filled floating minipans. In order to reduce measurement errors, evaporation rates were

determined in two-hour intervals over a period of six hours for the other six measurement days (three at the Cachoeira do Germano Reservoir and three at the São Miguel Reservoir). The six-hour period (approximately 9am to 3pm) was selected to record measurements during the hottest period of the day. For each time point, a plastic container with a tight-locked lid was filled with reservoir water (approximately 1000 g), and the actual mass of the water to ± 0.1 g was determined using a balance on shore. The water was then transferred to the minipan. After two hours (one hour during the first day of measurements), the water in the minipan was transferred back into the plastic container. The minipan was filled with water from a new plastic container whose mass had been measured as described above. The water that had been removed from the minipan was massed to determine the amount of water lost over the one or two-hour period. Wind speed, relative humidity, and air temperature were recorded hourly at each point using a handheld anemometer, while water temperature was recorded hourly with the Hawkeye DepthTrax Handheld Depth Finder. Air temperature, relative humidity, and wind speed and direction were also recorded hourly on shore about two meters above the surface area of the water using an Extech WTH600 wireless weather station during the measurement period.

3.3.2 *Climate data*

Hourly solar radiation (KJ/m^2) measurements were obtained from Quixeramobim Weather Station (coordinates: $5^{\circ}10'22.8''\text{S}$, $39^{\circ}17'13.2''\text{W}$; altitude: 227.33 m) monitored by the National Institute for Meteorology (INMET) were obtained online (tempo.inmet.gov.br). The Weather Station also provides hourly measurements for wind speed, air temperature, air pressure, and relative humidity. Daily rainfall data were obtained from the Hydrological Portal of Ceará (<http://www.hidro.ce.gov.br>).

3.3.3 Class A Pan data

Class A Pan data from a pan installed in the rural area of Manituba, Quixeramobim (coordinates: 5°21'11.0"S, 39°34'33.8"W; altitude: 269.8 m) were obtained from the Research Institute for Meteorology and Water Resources – Ceará State (FUNCEME).

3.3.4 Calculation of Evaporation Loss Coefficients

Analysis of variance (ANOVA) was used to calculate evaporation loss coefficients for a general linear model (multiple regression) based measured rate of water loss from the minipan (g/hr) and reservoir, minipan, and climatic variables. Reservoir variables included the reservoir itself (Cachoeira do Germano or São Miguel), the measurement day, and the location of the minipan on each reservoir based on depth (deep, intermediate, or margin). Minipans were made of one of two materials: plastic or aluminum. Climatic factors included time of day (late morning, midday, or early afternoon), wind speed, water temperature, air temperature, relative humidity, and VPD for each minipan location. VPD was calculated using the relative humidity, air temperature, and water temperature. The climatic conditions measured offshore or from the Quixeramobim Weather Station were not used in the coefficient calculations.

3.4 Results

ANOVA was carried out for different variables related to the reservoir, minipan used, and environmental conditions. Models were determined for the measurement day, the position of the minipan, climatic conditions (wind speed, relative humidity, barometric pressure, air temperature, and water temperature), the product [wind speed x VPD], and the reservoir versus minipan material

(Table 3.3). The calculated evaporation loss coefficients and their p values are presented in subsections 3.4.1 through 3.4.3.

Table 3.3 Model Results from ANOVA for Different Sets of Variables.

Model	Sum of Squares	Degrees of Freedom	Mean Squares	F ratio	P value
Day	94685	7	13526	4.9107	6.7987e-05
Minipan position	80685	6	13447	4.7201	2.4028e-04
Climatic conditions	62158	5	12432	4.1374	1.6829e-03
Wind speed x VPD	1.9776e+05	1	1.98e+05	54.292	2.123e-11
Reservoir vs. minipan material	52758	2	26379	8.7701	2.7624e-04

3.4.1 Reservoir Comparison

The evaporation loss coefficients and associated p-values for reservoir variables are presented in Table 3.4. The single-factor ANOVA carried out to compare evaporative loss between the Cachoeira do Germano Reservoir (four measurement days) and São Miguel Reservoirs (three measurement days) shows that the rate of evaporative loss was greater for the Cachoeira do Germano Reservoir than for the São Miguel Reservoirs. The evaporation loss coefficient was 35.094 ($p = 0.00056$). This result is overall consistent with the coefficients determined daily by reservoir (Figure 3.4a). The coefficients for the first three days of measurements at the Cachoeira do Germano Reservoir are greater than the coefficients for the measurement days at the São Miguel Reservoir. However, the coefficient determined for November 3, 2022 at the Cachoeira do Germano Reservoir deviates from this pattern. The coefficient comparing evaporative loss between the Cachoeira do Germano Reservoir and São Miguel Reservoir is also consistent with the coefficients calculated for minipan locations on each reservoir (Figure 3.4b): the coefficient of evaporation loss at each location based on depth (deep, intermediate, or margin) is greater for the Cachoeira do Germano Reservoir than for the São Miguel Reservoir.

Table 3.4 Evaporation Coefficients Calculated based on Reservoir Variables.

Variable	Condition (Reservoir)	Evaporation Loss Coefficient (g/hr)	SE	tStat	p value
Reservoir	Cachoeira do Germano vs. São Miguel	35.094	9.903	3.5437	0.00056
Day	28 October 2022 (Cachoeira do Germano)	115.34	12.37	9.3239	7.9818e-16
	31 October 2022 (Cachoeira do Germano)	88.726	12.37	7.1725	6.9892e-11
	1 November 2022 (Cachoeira do Germano)	93.294	12.37	7.5418	1.0505e-11
	3 November 2022 (Cachoeira do Germano)	38.207	12.729	3.0016	0.0032786
	21 July 2023 (São Miguel)	56.246	12.37	4.5468	1.3276e-05
	22 July 2023 (São Miguel)	45.307	12.37	3.6626	0.00037519
	24 July 2023 (São Miguel)	46.315	12.37	3.744	0.00028142
Minipan Location	Deep (Cachoeira do Germano)	89.841	10.895	8.2459	2.5007e-13
	Intermediate (Cachoeira do Germano)	110.46	10.895	10.138	8.6658e-18
	Margin (Cachoeira do Germano)	51.946	11.13	4.6673	8.0683e-06
	Deep (São Miguel)	45.756	12.581	3.6369	0.00040905
	Intermediate (São Miguel)	56.349	12.581	4.479	1.7327e-05
	Margin (São Miguel)	45.763	12.581	3.6376	0.00040817

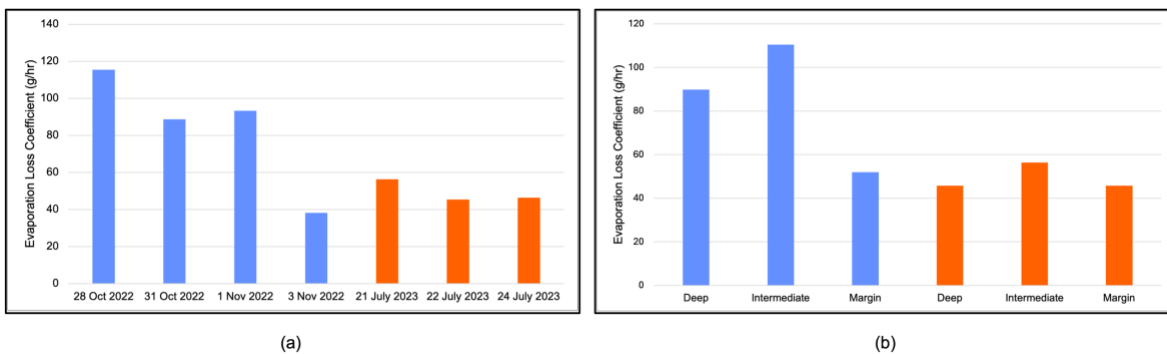


Figure 3.4 Evaporation Loss Coefficient vs (a) Measurement Days and (b) Minipan Position in the Cachoeira do Germano Reservoir (blue) and São Miguel Reservoir (orange).

3.4.2 Minipan Conditions

The ANOVA carried out for the material of the minipan (plastic or aluminum) using the values from seven measurement dates indicates a higher rate of evaporation for the aluminum pans (Table 3.5).

Table 3.5 Evaporation Loss Coefficient Calculated Based on Minipan Material.

Variable	Evaporation Loss Coefficient (g/hr)	SE	tStat	p value
Plastic (0) vs. Aluminum (1)	-21.656	9.8113	-2.2073	0.029164

3.4.3 Climatic Conditions

The evaporation loss coefficients were calculated for individual environmental conditions using measurement values taken at the minipan locations (Table 3.6, Figure 3.5). For wind speed, single measurement values taken at the beginning time for each two-hour interval were used. For the other variables, an average was taken using the measurements at the beginning time point, the hourly point, and the second hour. Climatic conditions, including air temperature and relative humidity, change over the course of the day. As such, evaporation loss coefficients were also calculated for the time of day (i.e., late morning, midday, and early afternoon) (Table 3.7, Figure 3.6).

Table 3.6 Evaporation Loss Coefficients Calculated Based on Climatic Conditions.

Variable	Evaporation Loss Coefficient (g/hr)	SE	tStat	pValue
Wind Speed	8.3273	3.6417	2.2866	0.023985
Relative Humidity	-2.1909	1.3937	-1.572	0.1186
Barometric Pressure	-5.2982	2.9545	-1.7933	0.075469
Air Temperature	-6.3704	6.6144	-0.96311	0.33745
Lake Surface Temperature	2.2983	4.9399	0.46525	0.6426
Wind Speed x VPD	1.2784	0.10233	12.493	1.10e-23

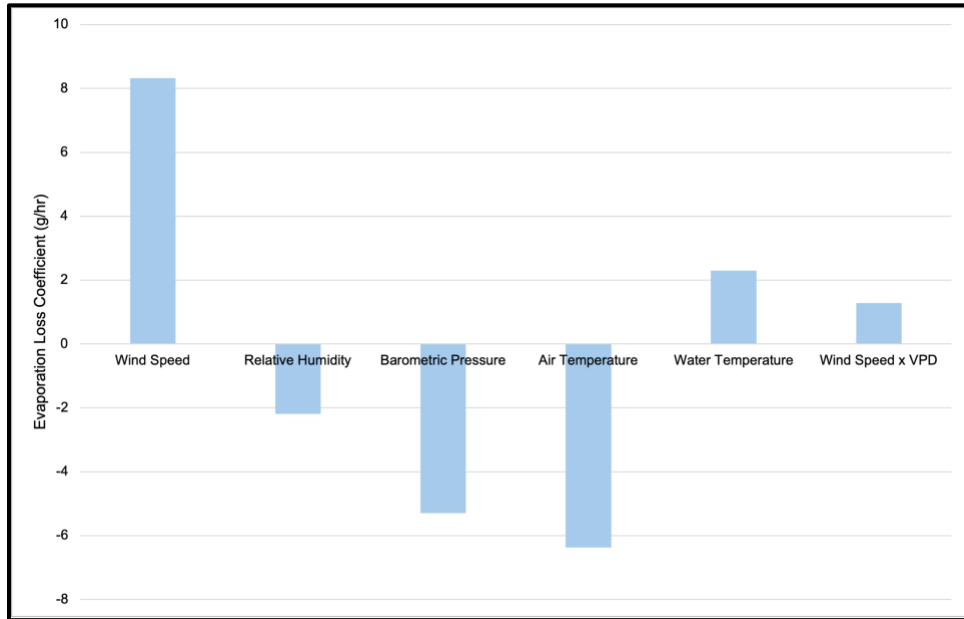


Figure 3.5. Evaporation Loss Coefficient vs. Climatic Conditions

Table 3.7 Evaporation Loss Coefficients Based on Time of Day.

Time of Day	Evaporation Loss Coefficient (g/hr)	SE	tStat	pValue
Late Morning	59.72	8.9792	6.6514	8.6916e-10
Midday	71.14	8.9792	7.9232	1.2253e-12
Early Afternoon	77.25	9.088	8.5001	5.5547e-14

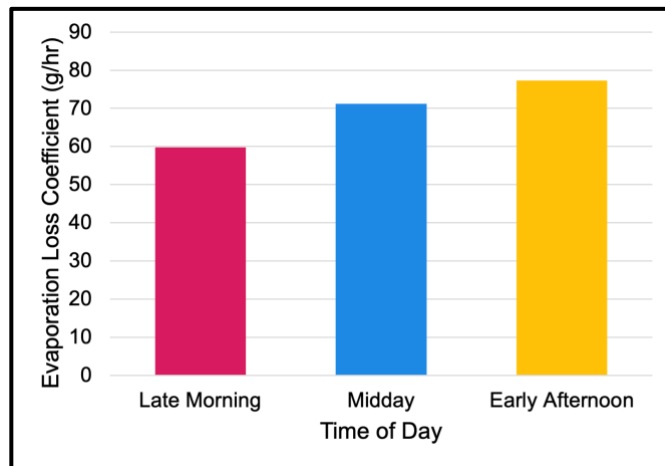


Figure 3.6 Evaporation Loss Coefficient (g/hr) vs. Time of Day.

3.5 Discussion

The analyses of the models derived from ANOVA using different sets of variables illustrate that both climatic variables and experimental design variables have significant impacts on evaporation loss coefficients. All five models have F ratios greater than 1.0 (minimum = 4.1374, maximum = 54.292), suggesting that the null hypothesis is false (i.e., the data are not sampled from populations with the same mean). Additionally, all five models had $p < 0.005$ (minimum = $2.123e-11$, maximum = 0.0016829), indicating that the models produce significant results.

The model that considers the product [wind speed x VPD] stands out for having the highest F ratio and the lowest p value and therefore the highest predictive value. This result supports the use of the Dalton model to estimate evaporation from reservoirs for sub-daily periods and with limited data. According to the Dalton model (Eq. 3.1), evaporation is a function of VPD (also called the Dalton factor) and wind speed (Li et al., 2017; Singh & Xu, 1997):

$$E = VPD * f(W) \quad (\text{Eq. 3.1})$$

where E represents free water surface evaporation, VPD is the vapor pressure deficit, W is the wind speed measured at a height of 1.5 m above the water surface, and $f(W)$ is the wind function. VPD, which is a factor of temperature and humidity, measures how much more water vapor the air can hold at a given temperature. A high VPD, for example, indicates that the air can hold more humidity and promotes evaporation from surfaces. Likewise, wind action plays a significant role in removing vapor and promoting evaporation from water surfaces (Vimal & Singh, 2022). In the present study, water temperature (a component of VPD) and wind speed were measured hourly at the minipan sites. However, such on-site measurements are not feasible for long-term evaporation

studies. Remote sensing is a promising method to determine monthly mean water surface temperatures of reservoirs (Alcântara et al., 2010), and evaporation studies could be carried out to evaluate the use of monthly mean temperatures to calculate VPD using a wind function determined empirically for the given reservoir.

The analyses of the individual reservoir variables further illustrate the influence of climate conditions at the reservoir and sub-reservoir scale. Evaporation loss coefficients were consistently higher for the Cachoeira do Germano Reservoir than the São Miguel Reservoir, as indicated by the coefficients for the comparison between the two reservoirs, the measurements on the individual days, and the minipan locations by reservoir (Table 3.4, Figure 3.4). The coefficient determined for the Cachoeira do Germano Reservoir on November 3, 2022 is an exception to this observation, although the p value associated with the coefficient is higher by at least one order of magnitude compared to the p values associated with the other measurement days. Additionally, the coefficient for the pan at the margin of the Cachoeira do Germano Reservoir is smaller than the coefficient for the pan at the intermediate depth of the São Miguel Reservoir. However, the margin coefficient is the smallest of the three location-based coefficients for the Cachoeira do Germano Reservoir, while the intermediate depth is the highest of the three location-based coefficients for the São Miguel Reservoir.

The evaporation loss coefficients are highest for the two reservoirs at the intermediate water depth compared to the location corresponding to the maximum depth and that corresponding to the margin (Figure 3.4b). While it is expected that the margin has the lowest evaporation loss coefficient, given potentially less wind exposure due to vegetation near the shore, the difference between the intermediate depth and deep locations is surprising, as for both reservoirs, the pans at the intermediate depth and deep positions had relatively the same wind exposure. To better

understand this observation, additional testing should be done to consider the affect of the measured climatic variables at the two locations for each reservoir, in particular the product [wind speed x VPD], which produced the evaporation coefficient with the greatest significance among climatic variables (Table 3.6).

The evaporation loss coefficient calculated to compare the use of plastic and aluminum minipans illustrates the importance of pan material in evaporation studies (Table 3.5). The analysis indicates that evaporation is faster from the aluminum pan than the plastic pan with a significant p value ($p = 0.00056$). The difference in evaporation rates can be explained by the difference in heat capacities of the two materials: aluminum's heat capacity is $0.904 \text{ J/g-}^\circ\text{C}$, while the heat capacity of polycarbonate plastics is $1.17 - 1.70 \text{ J/g-}^\circ\text{C}$ (MatWeb, 2024). As such, the aluminum pans will absorb less heat than the plastic pans over a measurement period. This results in more energy being stored in the water in the aluminum pans than that in the plastic pans and therefore potentially higher water temperatures and greater evaporation from the aluminum pans. The use of a pan-material appropriate coefficient is thus important when estimating evaporative loss from reservoirs using pans.

As discussed above, the climatic variable [wind speed x VPD] resulted in the evaporation coefficient with the lowest (i.e., most significant) p value. In fact, it is the only climatic variable that produced a coefficient with a p value < 0.005 . The higher p values of the other climatic variables may reflect the relatively low range of values and the precision of the instruments used to measure these variables over the study period. Despite this, the observed trends of the coefficients match the expected results for wind, water temperature, relative humidity, and air pressure. The positive wind coefficient indicates that increased wind will result in increased evaporation, which corroborates the Dalton method and other evaporation theories that indicate

that wind promotes evaporative loss. It is also expected that higher surface water temperatures will result in greater evaporation, as surface water molecules will have greater kinetic energy, promoting evaporation into the gas state. The negative coefficients for relative humidity and air pressure also corroborate evaporation theories. Lower relative humidity indicates less air water vapor, which promotes the flow of water from the water surface to the air and thus higher rates of evaporative loss. At the same time, lower air pressure facilitates the escape of liquid water on the surface to the atmosphere as a vapor. The evaporation coefficients related to time of day were also significant and followed an expected pattern: the highest coefficient was calculated for early afternoon, when air temperature is highest and relative humidity lowest.

The only climatic variable that did not follow the expected trend was air temperature. Air temperature is expected to have a positive correlation with evaporative loss, but a negative evaporation loss coefficient was observed. Despite this counter-intuitive observation, when air temperature is considered as part of VPD for the variable [wind speed x VPD], the expected trend is obtained with a highly significant p value.

3.6 Conclusion

Evaporation loss coefficients and models were developed using minipan evaporation measurements from the Cachoeira do Germano and São Miguel Reservoirs in the tropical semi-arid region of Ceará, Northeast Brazil. The study shows that use of minipans and in situ climatic measurements are adequate to model evaporation loss from free water surfaces. The relatively simple and inexpensive method corroborates evaporation methods that calculate evaporation as a factor of VPD and wind. Significantly, the differences in the evaporation loss coefficients for the

two reservoirs highlight the importance of considering microclimate conditions when estimating evaporative loss from free water surfaces.

In the continuation of this study, comparisons will be made between the minipan evaporation measurements and the evaporation measurements from the Class A pan located in the same region as the Cachoeira do Germano Reservoir. Given the importance of microclimate conditions on the evaporative loss from the reservoirs, it is expected that the Class A pan results will align more closely with the Cachoeira do Germano Reservoir than with the São Miguel Reservoir. The results of the minipan evaporation study will also be used in combination with long-term climatic data from the Quixeramobim Weather Station to estimate free surface water evaporation rates for the region at daily and monthly timescales. Greater understanding of the factors that influence evaporation from reservoirs can help improve evaporative loss estimates and inform reservoir design and location selection to minimize evaporative loss to the atmosphere.

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CHAPTER 4

DECENTRALIZED HYDRAULIC CITIZENSHIP: THE POTENTIALS OF RAIN- HARVESTING CISTERNS AS SOCIAL TECHNOLOGY TO TRANSFORM HYDRAULIC CITIZENSHIP IN RURAL NORTHEAST BRAZIL⁷¹

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Abstract

Since the early 2000s, household rain-harvesting cisterns have transformed hydrosocial realities across the rural interior of Northeast Brazil (NEB). Considered a social technology, the cement cistern not only increases household-level water security of impoverished rural families but also becomes imbued with consciousness raising, the dynamics of gendered water roles, and historically contextualized water values through its materiality and embeddedness socially and hydrologically. Federally funded cistern programs have led to transformations in rural hydraulic citizenship, or the ability of rural dwellers to be recognized through legitimate water services, in NEB. Cisterns and their human companions have become fundamental components of the decentralized water infrastructures that intend to support yearlong access to water in the rural areas of the Brazilian semi-arid region. The achievements, stagnancies, and challenges of cistern programs and the programs' rural beneficiaries attest to both the success of cistern building in NEB and its potential for more just hydrosocial relations into the future.

4.1 Introduction

It is midmorning when I arrive in Tunísia, a small rural community in the sertão, or hinterlands, of Ceará, Northeast Brazil (NEB). One hundred eighty slabs of freshly mixed concrete, neatly arranged into 20 rows, bask under the scorching sun quintessential to rural NEB. Each 40cmx50cmx4cm slab has been formed by the hand of a local bricklayer with the help of a trowel and wooden mold (Figure 4.1). While onlookers might think that the slabs are drying under the blazing rays of the sertanejo sun, the opposite is occurring. Water—transported from a community several kilometers away by motorcycle and donkey—is becoming fixed in place as it hydrates the compounds that make up the government-provided cement. As the hydration reactions continue,

newly formed hydrates and hydroxides aggregate with each other, forming a collective that will eventually give the concrete its rock-like strength. In the upcoming days, these slabs will be transformed into rain-harvesting cisterns, which will, in turn, transform the hydrosocial reality of four of the five households that make up Tunísia.



Figure 4.1 Two bricklayers finish forming the concrete slabs that were used to construct household rain-harvesting cisterns in Tunísia, Quixeramobim, Ceará in May 2022. (Source: Author)

Societies have practiced rainwater harvesting for millennia, yet in the semi-arid region of NEB, storing rainwater to use during the dry season was largely inaccessible to the rural poor until the turn of the 21st century. Without the means to construct cisterns to store water yearlong, impoverished rural families depended on small reservoirs, ephemeral streams, and *cacimbas*—large, shallow wells dug by hand—for water for drinking and cooking, in addition to other household uses. Members of the rural community Mearim I (a Quilombo community, or a community of descendants of enslaved Afro-Brazilians, in Quixeramobim, Ceará), for example, described how, as recent as 10 years ago, they and their children would walk to the cacimba, often kilometers away from their home. They would first drain the cacimba by hand, using buckets or

canisters to remove the *capa rosa* (iron oxide) and animal urine that the water of the open-aired well collected overnight. Once drained, the cacimba would begin to recharge, and rural dwellers would wait in line to fill their *cabaças* (gourds) in hand or *ancoretas* (small wooden barrels) carried on the backs of donkeys. With their gourds and barrels filled with the fresh groundwater, the women and children would make the journey home, where they would transfer the water to their *pote*, or clay barrel, filtering the water with a cloth. Once or twice a week, women would also wash clothes at the cacimba, taking care to prevent the soapy water from contaminating the cacimba's fresh water. Women elders of the community told me how they would chat, gossip, and enjoy their coffee with a cigarette, as they scrubbed and rinsed their families' clothing, letting the articles dry under the midday sun. Though often distant from the homes of rural families, cacimbas were integral to water relations in the sertão.

The daily relations between people and cacimbas have all but disappeared in many regions of NEB thanks to public projects to support the construction of household cisterns and community-level piped water systems. Rainwater stored in cisterns is primarily used for drinking and cooking, while households with running water will use this unpotable water, typically from a community reservoir or deep well, for other household uses. In the rural area of Quixeramobim, the cacimba of Mearim I is no longer visible through the brush. Never having interacted with a cacimba, children from the community were confused during a theatre improvisational activity I led in summer 2023, during which community members waited for the cacimba to recharge in order to retrieve water (Figure 4.2). Noticing their confused looks, I asked the children if they knew how it was possible to obtain water from the cacimba after it had been emptied to remove the dirty water. When they shook their heads, "No," the adult community members and I explained that water is stored below the surface of the ground. When the cacimba is empty, this sub-surface water

begins to fill up the hole, recharging the cacimba with fresh water. Within a generation, the knowledge of, and daily rituals involving, the cacimba have been replaced by new relations among people, rain-harvesting cisterns, and in-home plumbing. In what follows, I examine the formation of a new type of “hydraulic citizenship,” that is, the ability of residents to be recognized through legitimate water services (Anand, 2017, p 8), in the sertão by way of public cistern programs and the values embedded in the decentralized infrastructure networks these social technology⁷² programs help establish.



Figure 4.2 Quilombo Mearim residents improvise a scene in which community members collect water from a cacimba during a theatre workshop held in July 2023. (Source: Author)

In 1999, a consortium of civil society organizations called ASA (*Articulação no Semiárido Brasileiro* or Dialogue in the Brazilian Semi-Arid Region) developed the Program One Million Cisterns (*Programa Um Milhão de Cisternas*, P1MC) to improve access to potable water and to mobilize rural families and communities in the Brazilian semi-arid region through the construction of household rain-harvesting cisterns. Families did not just receive a cistern from the program but

⁷² In this context, “social technology” does not refer to technologies such as the Internet or social media, which digitally mediate social interactions, but rather is the translation of *tecnologia social*, defined as a “set of techniques, transformative methodologies, developed and/or applied in interaction with local groups of people and appropriated by them, which represent solutions for social inclusion and improvement of living conditions” (Instituto de Tecnologia Social Brasil [ITS Brasil], 2004: 26).

were also included in each step of the cistern-construction process to cultivate the understanding of water as a right and the cistern as a family achievement (Articulação no Semiárido Brasileiro [ASA], n.d.a). Subsequently, the Brazilian Federal Government established *Programa Cisternas* (Program Cisterns) in 2003, during the first presidential mandate of Luiz Inácio Lula da Silva, more commonly known as Lula. In 2013, the Program was instituted into law as *o Programa Nacional de Apoio à Captação de Água de Chuva e outras Tecnologias Sociais – Programa Cisternas* (the National Program to Support Rainwater Harvesting and Other Social Technologies – Program Cisterns) (Brazil, 2013). Its name speaks directly to one of the drivers of the program and its origins: the development of social technologies to support rural dwellers.

As a concept, “social technology” is premised on community interaction, community empowerment, and social transformation.⁷³ Social technologies have four dimensions: social relevancy; knowledge, science, technology, and innovation; education; and participation, citizenship, and democracy (ITS Brasil, 2023). A social technology should be replicable, developed with communities, and provide effective solutions that promote social transformation (Jesus & Costa, 2013). The term emerged from critiques of the model of Appropriate Technology (AT), which became popular in the 1960s and 1970s to address technological development in the lesser economically developed Global South (Ventura et al., 2012). AT champions technological choice based on an area’s psychosocial and biophysical contexts (Willoughby, 1990). Unlike the AT movement, the Social Technology movement prioritizes democratic participation and social transformation through socially-relevant technological processes and devices (Ventura et al., 2012). In Brazil, a Federal Social Technology Policy that defines social technology and recognizes

⁷³ The moniker “social technology” may suggest that only technologies oriented toward democratic principles are social. However, all technological devices are social (Latour, 1999). Society and technology are co-produced through processes of making identities, institutions, discourses, and representations (Jasanoff, 2004). The term “social technology” is not meant to negate the social dimensions of other technological devices and processes.

its importance was initially proposed in 2011 (Rollemberg, 2011) and reintroduced to Congress in 2015 (Rollemberg, 2015).

The Social Technology understanding of technology as a means toward social liberation echoes debates in philosophy of technology over the past century. Marcuse (1964) and Ellul (1954) caution against the domination of politics and social values by the rational technical society. Both argued that liberation from oppressive forms and uses of technology would require a complete transformation of society through a concerted struggle against this form of domination, a struggle catalyzed by collective consciousness-gaining or uprising from the margins of society. Yet how this mass movement would materialize remains unaddressed in their works. Feenberg (1999, 2001) envisions the realization of the societal transformation alluded to by Marcuse and Ellul through the deep democratization of technology, which consists of combining public control over technical institutions with the democratic rationalization of “technical codes,” defined as “the realization of an interest in a technically coherent solution to a problem” (Feenberg, 2001, p. 189). Technical codes assume the existence of many solutions to a particular technical problem. In NEB, for example, harvesting rainwater with a cement cistern or polyethylene cistern are two possible solutions to solve the issue of lack of access to potable water. However, these two technological artifacts “do” different things due to differences in means and modes of production (Verbeek, 2005). The democratization of technology called for by Feenberg (1999) requires change in the structure and knowledge base of technical management and demands the incorporation of public agency into the standard procedures of technical design. As Novaes and Dias (2010) observe, the Social Technology movement is premised on the transformations Feenberg champions. As a social technology, the cement rain-harvesting cistern actively participates in work toward Feenberg’s technological democracy.

The potentials and limitations of the work carried out by the rain-harvesting cistern toward democracy must be contextualized within the legacies of clientelism that characterize the region. Patronage relationships have defined the rural poor's access to basic goods and services, including water, since Portuguese colonization (Nelson & Finan, 2009). In NEB, clientelist relationships were initially between the wealthy land-owning elite (*coroneis*) and the rural poor. However, the unequal power relations between politicians and the citizens who elect them is the primary mode through which patronage is maintained in NEB today (Bedran-Martins & Lemos, 2017). Toward the end of the 20th century, the government at local, state, and federal levels began to replace the land-owning elite as the rural poor's patron, helping rural dwellers survive intense drought periods by providing cash transfers, water delivery, and food baskets, among other services (Nelson & Finan, 2009). Today, small farmers' vulnerability to drought is often related to these contemporary clientelist relations (Kenny, 2002; Lemos & de Oliveira, 2004). Nelson and Finan (2009) argue that participatory decision-making and government investment in local infrastructure and human capital are required to move away from these relationships of chronic dependency and toward greater sociopolitical parity for the rural poor. The cistern program developed by ASA and later incorporated into federal government planning is one possible mechanism toward greater citizenship—at least in terms of divorcing access to drinking water from voting power. Nonetheless, rural dwellers continue to navigate and negotiate these rights, particularly with municipal-level politicians, in order to achieve access to other basic needs, including healthcare and water for household uses.

Observed as dots adjacent to homes and schools on satellite imagery, cisterns are social technological artifacts that contribute to water infrastructure and hydraulic citizenship across the rural hinterlands. Whereas Anand (2017) focuses on the centralized hydraulic infrastructure of

cities in his analysis of hydraulic citizenship, to understand the formation of rural hydraulic citizens in NEB, attention must turn to decentralized infrastructure systems. Conversations regarding decentralized water infrastructure typically focus on community-based water management systems, characterized by communal water systems with decision-making, distribution systems, and water sources decentralized to the community or intercommunity level (e.g., Garn & Katz, 1997; Hutchings et al., 2015; Whaley & Cleaver, 2017). However, cisterns—and the water that both constitutes part of their molecular structure and is stored as a source of water— form part of a decentralized water infrastructure centered around the household.

Most households in the rural area of Quixeramobim that I visited get water from two types of decentralized water infrastructure: a community-based piped water system that provides unpotable running water from a small reservoir or well and a household cistern used to harvest rainwater for drinking and cooking.⁷⁴ Water stored in household cisterns flows not through pipes but rather is transported from the cistern to a household in discretely packaged units of buckets or barrels by people typically on foot or motorcycle or by animal companions, including donkeys. Cisterns promote diverse types of water sharing between households in the same village or across different villages. The water that enters the cistern is usually rainwater that falls on the roof of a family's home and travels through a system of connected gutters and PVC pipes. At times, however, the water in a cistern may be from a water truck (*carro pipa*). Cisterns facilitate the movement of water by capturing and storing it.

⁷⁴ In this context, decentralized community-level water infrastructure is contrasted to water services provided by the municipal water authority (*Serviço Autônomo de Água e Esgoto*, SAAE) or the Water and Sewage Company of Ceará (*Companhia de Água e Esgoto do Ceará*, CAGECE). In Ceará, a municipality provides water to urban areas through a municipal-level SAAE or through CAGECE. In Quixeramobim, water is provided by SAAE, and in addition to urban centers, SAAE also provides water to some rural communities. However, the majority of rural communities with running water carry out their own management of a community-level system, typically constructed through a state or federal public program, such as the state-level program *Projeto São José*.

Like other technological artifacts, the cistern embodies particular sociopolitical and environmental values and realities through its physical structure (Miller, 2020; Winner, 1980). The standardized building parameters are the result of contextualizing the technological device to the region and its people. Construction materials including cement and metal wire are provided by the government program. However, the water used to construct the cistern, typically sourced from the community itself, varies, and its quality can impact the cistern's structural integrity. Maintenance also varies, in this case from household to household, because while guidelines are provided during the initiation capacity training, reinforcement of those guidelines in the form of technical or financial support does not exist. Resources for repairing broken or decommissioned cisterns are not provided by the government program either. Monitoring and maintenance, which form part of the latter part of the infrastructure lifecycle described below, are forgotten in the politics of cisterns.

As a social technology, the household rain-harvesting cistern embodies social and political values throughout the infrastructure lifecycle of Brazilian public cistern programs. The infrastructure lifecycle refers to the process of infrastructure development, from conception, planning, budgeting, and design, to implementation and monitoring and maintenance, with potential replacement or decommission (Figure 4.3, Sohail & Cavil, 2008; Wells, 2015). It is regularly used by engineers and other technicians to evaluate infrastructure projects based on economic and material indicators. In particular, projects are often assessed in terms of budgets for execution and lifecycle management (which may include operation, management, maintenance, rehabilitation, adaptation, and decommissioning and disposal) (Klerk & den Heijer, 2016).

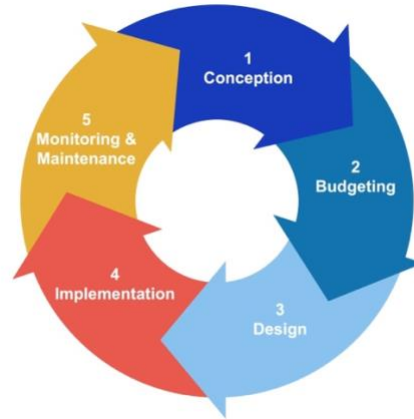


Figure 4.3 The five phases of the infrastructure lifecycle: Conception, Budgeting, Design, Implementation, and Monitoring & Maintenance.

In the context of public cistern projects in NEB, the latter phases of the infrastructure lifecycle are neglected by the public sphere, the responsibilities for maintenance and replacement relegated to individual households. Yet, in many cases, families do not have the means to repair or replace a cement cistern that has broken. As I examine in the section “Monitoring & Maintenance: Fluidity and Stagnancy,” hydraulic citizenship, in a sense, deteriorates with the physical deterioration across the infrastructure lifecycle. In this paper, I use the infrastructure lifecycle as a mechanism to examine the relationship between the cement rain-harvesting cistern and the ebbs and flows of hydraulic citizenship.

During two years of in-person fieldwork in the rural area of Ceará, Brazil, I accompanied cisterns throughout their lifespans—from the selection of where cisterns would be constructed, to community mobilization meetings, cistern construction, and many cisterns’ long-term dilapidation. Drawing on (critical) philosophy of technology and Anand’s (2017) concept of the hydraulic citizen, my analysis examines the integration of rural dwellers into a particular decentralized water regime and how hydraulic citizenship evolves through this process. I use key phases of the infrastructure lifecycle—conception, budgeting, design, implementation, and

monitoring and maintenance—to contextualize the cistern’s material and social character and to trace changes in hydraulic citizenship. I argue that government-sponsored cistern programs have greatly increased household water security and have encouraged local empowerment in NEB. Yet rural hydraulic citizenship remains tenuous, dependent on the federal government’s investment and on citizens’ (lack of) recognition of their right to water.

4.2 Conception: A New Way to “Live With” Drought and the Semi-Arid Region

The infrastructure lifecycle begins with conception, or the formal and informal ways the idea for particular infrastructure is conceived and then goes into a formal review procedure. The phase often defines a project’s objectives, scope, and scale. The conception of public cistern programs in Brazil is contextualized within the cultural imaginary and political legacies of NEB. It reflects the changing of development paradigms away from the corruption of the “Drought Industry” and toward visions of sustainable coexistence with drought and the semi-arid environment. It also responds to social movements’ push toward greater democratic access to water and other basic needs for marginalized communities, supporting the hydraulic citizenship of the rural poor.

The cultural imaginary of NEB is saturated by drought and drought-related misery (Albuquerque Jr., 1999; Seigerman et al., 2021). The majority of the region experiences a tropical semi-arid climate and forms part of the “Drought Polygon,” a geographic territory initially established by federal legislation in 1936 that includes municipalities in the states of Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe, Bahia, and Minas Gerais. NEB is infamous for the “Drought Industry,” or corruption and the financial gain by the political and industrial elite at the expense of the rural poor through the construction of large water infrastructure

throughout the 20th century (Alves da Silva, 2007). The Drought Industry and public policies promoting large-scale water infrastructure are intimately tied to the modernist paradigm “*Combate contra a seca*” (“Fight against drought”) (Alves da Silva, 2007). This bellicose approach continues to guide policy and remains ever-present in the name of DNOCS, the National Department of Works Against Drought (*o Departamento Nacional de Obras Contra Seca*).

Towards the end of the 20th century, however, a new paradigm espousing a more peaceful and less combative coexistence with the semi-arid region materialized: “*Convivencia com o semiárido*” (“Living with the semi-arid region”). This paradigm, which emerged out of global conversations on sustainable development, promotes a more holistic coexistence between people and the Caatinga, the dry forest landscape that dominates the sertão (Alves da Silva, 2007). As efforts to promote sustainable living in the semi-arid region through equitable access to natural resources, household cistern programs and other social technologies are premised on the “Living with the semi-arid region” paradigm (Alves da Silva, 2007). Unlike the large-scale infrastructure projects that primarily benefit the elite class, social technologies provide new ways for the rural poor to live well and “live with” the semi-arid region.

ASA’s P1MC has taken concrete actions to substantiate equitable and democratic water, prioritizing the rural poor and maintaining separation from municipal governments (*prefeituras*) that could potentially co-opt the program for political gain through client-patron relations. Low-income rural families who face drought or experience lack of water access regularly constitute the beneficiaries of the programs (Brazil, 2013). The programs prioritize Indigenous and traditional communities, including Quilombos, in addition to women-led households and households with school-aged children, elderly members, and/or members with physical deficiencies. Families must be registered in *Cadastro Único*, a federal registry of low-income families through which families

become eligible to receive social benefits, including Bolsa Família (the Brazilian federal government cash transfer program) (Ministério do Desenvolvimento e Assistência Social, Família e Combate à Fome [MDS], n.d.). Cadastro Único and federal programs including Bolsa Família are administered by the prefeitura, meaning that access to P1MC is affected by the local government. However, ASA seeks to avoid engagement with local politicians through the establishment of municipal commissions and Microregional Management Units (UGMs), which manage cistern projects in a given municipality (Andrade & Cordeiro Neto, 2016). Participating families work directly with these administrative bodies, rather than with the prefeitura or local representatives (*vereadores*). This is meant to prevent local politicians from capitalizing on patron-client relations that have defined rural access to basic goods and services for centuries.

Over the past two decades, several initiatives have contributed to making household cisterns accessible to rural families, embodying the “living with the semi-arid region” paradigm. The most well-known projects include the Dom Helder Câmara Project (DHCP), ASA’s P1MC and *Programa Uma Terra e Duas Águas* (One Earth and Two Waters Program, P1+2), Program Cisterns, *Programa Água para Todos* (Water for All Program, APT), and the Paulo Freire Project in Ceará. Cistern projects associated with these programs have been implemented primarily across the semi-arid region of Brazil, more specifically across the area where the Superintendency of Development of the Northeast (SUDENE) operates—a legislatively delineated geographic area that currently includes all of the states of NEB (Maranhão, Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe, and Bahia), in addition to 249 municipalities in the state Minas Gerais and 31 municipalities in Espírito Santo (Brazil, 2007a). APT eventually expanded its cistern-building program to some municipalities facing water scarcity in Amazonas, Espírito Santo, Goiás, Pará, Rio Grande do Sul, Santa Catarina, and Tocantins (Nogueira et al., 2020). The

majority of the cisterns constructed through these projects are 16,000 L household cisterns for drinking and cooking, while some programs also fund the construction of “production cisterns” with volumes of 52,000 L to provide water for crop and animal cultivation. The conceptualization of cistern programs supports the hydraulic citizenship of the rural poor by focusing on improving quality of life of these populations through democratic access to water for drinking, cooking, and livelihood activities.

4.3 Budgeting: Drought, Continued Hope, and Renewed Commitment

The budgeting phase of the infrastructure lifecycle helps to determine the feasibility of an infrastructure project by establishing monetary spending limits. From the initial conception of the federal cistern program in 2003 until present, the budget associated with the program has depended greatly on the priorities of the federal government with tangible impacts on rural hydraulic citizenship. The year 2016 was marked by climatic and political turmoil and drought that harmed the hydraulic citizenship of NEB’s rural poor. NEB experienced its fifth consecutive year of drought in 2016, and across rural municipalities, like Quixeramobim, Ceará, large and small reservoirs were drying out, water systems in urban and rural areas were collapsing, and the rural poor became dependent on federally funded water-truck services. Meanwhile, in August of that year, Brazil’s president, Dilma Rousseff, was impeached, removed from office, and replaced by her vice president, Michel Temer. Seven years later, in August 2023, the Regional Federal Court of the 1st Region would unanimously decide to acquit Rousseff for the financial crimes related to the Petrobras scandal that led to her impeachment. However, her acquittal could not undo the government consolidation and progressive decline in cistern construction that characterized the presidencies of Temer and Jair Bolsonaro from 2016 to 2022 (Figure 4.4).

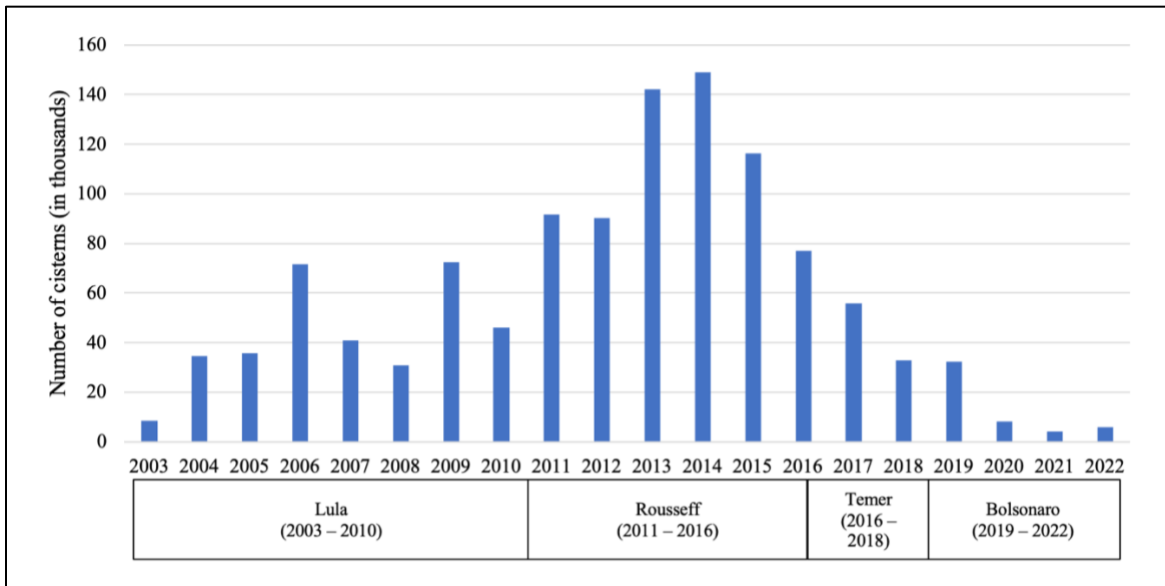


Figure 4.4 Cisterns built through Program Cisterns from 2003 until 2022 during the presidential mandates of Luiz Inácio “Lula” da Silva (2003 – 2010), Dilma Rousseff (2011 – 2016), Michel Temer (2016 – 2018), and Jair Bolsonaro (2019 – 2022). (Source: MDS [2023, August 1])

During the governments of Temer and Bolsonaro, priorities shifted from concern about the wellbeing of rural poor to the interest of agribusiness and large landowners. Upon entering office, Temer consolidated his government and altered the name and focus of eight ministries, including the ministry in charge of Program Cisterns and other public programs, the Ministry of Social Development and the Fight Against Hunger (MDS) (Nobre, 2016). The MDS was replaced by the Ministry of Agricultural Development (MDA), which was viewed by many, including ASA, as a move to prioritize the interests of agribusiness and large landowners over those of family farmers (ASA, n.d.b). Temer’s actions foreshadowed the prolonged and severe drought experienced by Program Cisterns during Bolsonaro’s mandate (2019 – 2022). In December 2021, ASA published an open letter denouncing Bolsonaro’s government for destroying Program Cisterns and thus condemning the population of the Brazilian semi-arid region to famine and death (ASA, 2021).

Rather than lose faith, ASA maintained hope, which, as Paulo Freire (1970, 92) observes, “[...] does not consist in crossing one’s arms and waiting. As long as I fight, I am moved by hope; and if I fight with hope, I can wait.” To combat the “inhumane” stance of the Ministry of Citizenship (MC), which had assumed responsibility for Program Cisterns during Bolsonaro’s mandate, ASA called for societal solidarity, upholding the principles of social technology, democracy, and hope for liberation: “We call on society to join us in this fight so that the Brazilian State can once again assume public policies that guarantee the dignity of the Brazilian people. We cannot allow our rights to continue to be neglected due to partisan political interests” (ASA, 2021). Around that time, ASA also launched the “I’m Thirsty” (“*Tenho Sede*”) fundraising campaign to raise money for cistern construction, with support from the Northeast Governors' Forum and the Forum of Family Agriculture Secretaries.⁷⁵ Significantly, ASA acknowledged that their “campaign does not replace the role of the State,” and continued to hold the federal government accountable for not only upholding its contractual obligations but also fulfilling its role “to guarantee the rights of the Brazilian people, especially the poorest” (ASA, 2021).

UGMs at the local level also maintained hopefulness by carrying out strategic actions to raise funds to continue to build cisterns despite the lack of federal funding. For example, in 2022, the Antônio Conselheiro Institute (IAC), a non-government organization located in Quixeramobim that acts as the regional UGM, carried out the construction of 113 cisterns in the municipality of Quixeramobim without federal funding. In 2023, IAC carried out a similar project, constructing 101 cisterns in the municipality (Director of IAC, personal correspondence, March 23, 2023). From 2016 until 2023, ASA, its collaborators and supporters, and rural dwellers still waiting for

⁷⁵ The campaign continues to be active into January 2024, and donations can be made through the campaign’s website or, in Ceará, via one’s water bill from the Water and Sewage Company of Ceará (CAGECE) (<https://www.tenhosedede.org.br/>, 2024).

their opportunity to obtain a cistern continued to cultivate hopefulness, which, as bell hooks (2003: xiv) reminds us, “[...] empowers us to continue our work for justice even as the forces of injustice may gain greater power for a time.”

In 2023, Program Cisterns commemorated its 20th anniversary with renewed spirit and federal support. In July 2023, Lula’s government officially announced the resumption of Program Cisterns with an investment of more than 562 million BRL (about 114 million USD) and reestablished contracts and partnerships (MDS, 2023, August 1). On Instagram, IAC published stories and posts commemorating the act and its participation in the Program Cisterns Planning Workshop led by AP1MC, which took place in Recife, Pernambuco, NEB in November 2023 (Figure 4.5). In January 2024, IAC held its first training workshop for *cisterneiras* and *cisterneiros*, rural residents who will help construct 770 cisterns as part of the renovated Program in the rural interior of Ceará. While 2023 marked the end of the seven-year drought faced by Program Cisterns, FUNCEME and the Secretariat of Water Resources of Ceará (SRH) began to brace themselves for a potentially devastating 2024 rainy season and meteorological drought due to El Niño. This imminent and cyclical threat to the livelihoods of the rural dwellers highlights the importance of budgets that include investments in Program Cisterns and other public policies that promote “living with” drought and the semi-arid region.

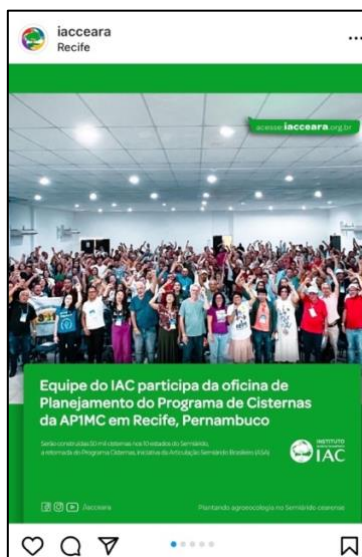


Figure 4.5 An Instagram post by IAC on their participation in the Program Cisterns Planning Workshop led by AP1MC in Recife, Pernambuco, NEB in November 2023. (Source: Instagram)

4.4 Design: The Makings of a Cistern

During the design phase of the infrastructure lifecycle, the infrastructure design is determined, with consideration of budgetary constraints and regulatory demands. The design of the cistern constructed through the federal cistern program—including the cistern’s material composition, building process, volume, and color—embodies the values of the Social Technology movement in Brazil adapted to the dynamic socio-natural processes of NEB. Over the past two decades, the curved body and cone-shaped top of the 16,000 L cement cistern have become ubiquitous across the sertão of NEB by design (Figure 4.6). The cement cistern adopted by P1MC and Program Cisterns was invented in the 1950s by Manoel Apolônio “Nel” de Carvalho, an illiterate rural dweller from NEB who learned about pre-molded concrete slab while working as a pool construction worker in São Paulo (Santos Neve et al., 2010). When he returned to his home in NEB, he created a new cistern model, consisting of a cylindrical base made out of curved pre-molded concrete slabs. That the technology adopted by ASA originates from the knowledge of a

local subsistence farmer exemplifies the Social Technology movement's value that social technologies should "expand the notion of knowledge—traditional, popular knowledge and experiments carried out by the population as well as technical-scientific knowledge can constitute a source for generating solutions" (ITS Brazil, n.d.). It also instantiates people intervening in the design of the technical artifacts with which they interact in everyday life, which Feenberg considers, "[...] an essential dimension of the contemporary struggle for a humane and livable world" (Feenberg, 1999, p. 199). The origin of the cistern construction process further embodies the movement's beliefs in the ability of all people to generate knowledge and to learn (ITS Brazil, n.d.). The concrete cistern's presence across NEB is a testament to the ingenuity of Northeastern family farmers.



Figure 4.6 A household rain-harvesting cistern in the rural area of Quixeramobim, Ceará, Brazil, November 6, 2021. (Source: Author)

The use of concrete slabs is fundamental to the cistern's identity as a social technology not only because it embodies respect for local populations but also because of the interactions between concrete and local people during cistern construction. Concrete, the second-most consumed material in the world behind water (Gagg, 2014), is a relatively inexpensive building material. The use of concrete to construct cisterns facilitates a low-cost and reproducible process that

economically benefits local people who are trained to construct cisterns during bricklaying courses offered by the public cistern programs. Community involvement, replicability, low cost, and benefits to the local community beyond the artifact itself are fundamental to a social technology (Jesus & Costa, 2013). Concrete cisterns have these characteristics.

Despite its essential role as part of social technologies, concrete—and, in particular the cement used to make it—is not totally benign as a material. While in itself, concrete has a very low carbon footprint compared to other materials, given the volume of Portland cement used in construction worldwide, the cement industry emits a significant amount of carbon dioxide (Barcelo et al., 2013). The cement used in industry produces about seven percent of global atmospheric carbon dioxide emissions, where about 95 percent is due to the production process and five percent associated with the transportation of raw materials and cement-based composites (Fantilli et al., 2019). Each household receives 16 50-kg bags of compound Portland cement from Program Cisterns to construct their cistern (Programa Cisternas, 2021, March 24).⁷⁶ Local brick masons trained through the Program combine the cement with sand and water to create the concrete slabs they will assemble to construct the cisterns.

Polyethylene cisterns were integrated into federal cistern programs in 2012 under the premise that the plastic cisterns would increase the speed of implementation and thus more effectively attend to the immediate needs of rural families (Campos & Melo Alves, 2014). Polyethylene is the most commonly produced plastic. It is highly stable and used for a variety of products, including plastic bags, artificial joints, and storage containers. The Ministry of National Integration (MI) was responsible for the contracting and implementation of the polyethylene

⁷⁶ Compound Portland cement has the addition of slag, composed of additives increase the initial resistance and decreases the probability of cracking due to thermal expansion (CSN, 2020).

cisterns (Campos & Melo Alves, 2014). Two private companies, Acqualimp and Fortlev, were awarded contracts through a public solicitation process (Campos & Melo Alves, 2014). Like their concrete counterparts, the polyethylene cisterns have a volume of 16,000 L.

However, the incorporation of polyethylene cisterns into APT undermined the essence of the household cistern as a social technology, and the shift from cement to polyethylene was fraught with controversy. First, in December 2011, ASA denounced the federal government for ending Program Cisterns in favor of APT and the plastic cisterns the program promised (Calheirs, 2012). Second, the polyethylene cisterns cost more than double the price of the concrete cisterns: in 2012, the cost of a polyethylene cistern was 5,000 BRL (about 2,750 USD), while the cost of a cement cistern was about 2200 BRL (about 1,300 USD) (Madeiro, 2012). Third, although polyethylene is a robust plastic, a non-disclosed defect in the construction of various polyethylene cisterns installed in 2012 through APT resulted in cisterns melting under the intense sun of the semi-arid hinterlands (Figure 4.7). In 2012, ASA began the campaign “Cisternas de Plástico/PVC – Somos Contra!” (“Plastic/PVC Cisterns – We Are Against Them!”) to protest the government’s use of polyethylene cisterns (ASA, n.d.c; Nogueira et al., 2020). The protest campaign led by ASA counted with the support of rural workers’ unions and civil society organizations, including IAC. Only cement cisterns are considered a social technology by ASA and local non-government partners (President of IAC, personal correspondence, October 13, 2021). In one statement, Mauro Macedo, the director of the Society of Educational and Technological Actions, proclaimed that the use of polyethylene cisterns was “[...] a setback that could result in the return of the old practices of the Drought Industry, where families are once again placed as hostages of politicians and companies, taking away their right to build their history” (Santana, 2013).



Figure 4.7 A functional polyethylene cistern (a, photo source: Fatos e Fotos da Caatinga, 2012) and defective polyethylene cistern (b, photo source: AS-PTA, 2013) provided to rural dwellers through the Water for All (APT) program in 2012.

In response to the public backlash, the Development of the São Francisco Valleys and of Parnaíba Company (CODEVASF), one of the entities in charge of APT, released a statement stating that less than one percent of the polyethylene cisterns had the observed defects, any cistern with a defect would be replaced immediately, and a new model without the defect was being produced and distributed (Assessoria de Comunicação do Deputado Gonzaga Patriota, 2012). CODEVASF also defended the use of polyethylene cisterns in terms of benefiting the local economy, stating that the cisterns were being produced in local factories and counted on the work of local people as drivers, bricklayers, and construction workers, among other positions (Assessoria de Comunicação do Deputado Gonzaga Patriota, 2012).

Despite overall providing an effective solution to the problem of lack of access to potable water, that the polyethylene cisterns were only replicable by the industrial producers and installed premade compromised many of the values associated with social technologies. Program beneficiaries were still responsible for digging the holes for the installation of the polyethylene cisterns, but local masons were not sought out, as the contracted company delivered and installed the cisterns. The protests by farmers' unions, non-government organizations including IAC, and

ASA highlight the contrast between the values embodied by cement and polyethylene cisterns. Notwithstanding the controversies surrounding the implementation of polyethylene cisterns, the majority of these cisterns successfully contributed to improving access to potable water of impoverished rural dwellers. As a former State Secretary of Water Resources of Ceará commented over lunch one day: once, when he once asked a farmer what type of cistern the farmer preferred, the farmer responded that he preferred one with water in it (personal correspondence, August 2022). Given the limited distribution of polyethylene cisterns in Ceará, I never met a family with this type of cistern. However, the former State Secretary of Water Resources of Ceará's anecdote resonates with the gratefulness the rural families I met expressed when discussing the ability to use rainwater yearlong. APT was suspended, and polyethylene cistern installation discontinued, in 2018. While the program was reestablished in 2023, whether or not polyethylene cisterns will also return is unclear.

Despite the greater embodiment of Social Technology values by cement cisterns than by polyethylene cisterns, the physical environment can provide challenges to the replicability of cement cisterns. In particular, making concrete from cement requires water, and, especially during drought periods, limited water availability and quality may hinder the construction of concrete cisterns. Residents of Tunisia, for example, who did not have a reliable water source before cistern construction, were unsure where the water to construct the four cisterns for their community would come from (Community leader of Tunisia, personal correspondence, May 10, 2022). At that time, the households depended on water that was delivered every month by truck and deposited into a communal tank. That water, however, usually lasted only two weeks, and residents would retrieve water from neighboring communities located kilometers away, as nearby reservoirs had dried up during the most recent drought period. The situation could have been prime for local politicians to

“trade” water for voting power with the residents of Tunisia. But this was avoided. The community leader made the community’s needs known to IAC, the entity carrying out the project, and discussed possible ways to obtain water for cistern construction with the non-government organization. In the end, community members counted on relatives and friends in neighboring communities for the necessary water, which they transported by motorcycle and donkey (Community leader of Tunisia, personal correspondence, May 11, 2022). Despite the initial challenge to obtain water, the solution carried out by Tunisia residents illustrates their sense of empowerment to determine the conditions of the project to construct their cisterns.

In addition to the water used in cistern construction, the volume of water (16,000 L) reflects NEB’s semi-arid climate patterns. The volume is considered a sufficient volume to supply a family of up to six members with water for drinking and cooking during the dry season, or up to eight months (ASA, n.d.a) In addition, the white exterior of these cisterns, which comes from a coat of limewash (*cal*) speaks to the region’s climate and the accessibility of building materials. Limewash is relatively inexpensive, is easy to apply, and effectively protects the concrete structure from weathering due to sun and rain. Unlike the dark exterior of polyethylene cisterns, the white cistern top and walls help reflect sunlight, reducing heat absorption. It is recommended to apply a new layer of limewash yearly, yet despite recognizing the benefits, many of the families I worked with admitted that they rarely carry out the practice.

The materiality of the cement cistern embodies not only the values of social technologies but also climate and political processes in NEB. The immense backlash catalyzed by the implementation of the polyethylene cistern attests to the morals associated with rain-harvesting cisterns as social technology, including the desire for the prosperity of the rural poor through social transformation. Although the polyethylene cisterns were designed to increase the rural poor’s

access to potable water, they undermined this access as well as other democratic principles espoused by the cement cistern and the Social Technology movement.

4.5 Implementation: Training New Hydraulic Citizens

During implementation, an infrastructure project transitions from design to construction. With the launch of P1MC and Program Cisterns, government-funded cisterns began to flood the Northeast, transforming the lives of rural families. While P1MC and the other cistern programs are defined by particular objectives, funding sources, and associated institutions, for most rural dwellers, the program itself is irrelevant and oftentimes forgotten. Rather, conversations underscore the radical differences in hydrologic realities before and after receiving a cistern. In one interview, a 61-year-old *assentado* (settler on a federal or state *assentamento* or settlement), observed, “[Life] changed. It was a source of wealth for us to have rainwater at home. Before, it was horrible. I had to retrieve water from the reservoirs.”⁷⁷ The cistern is often described as a *bença* (blessing)⁷⁸ and “the best thing the Government has done”⁷⁹; life before and after receiving a cistern considered “incomparable.”⁸⁰ The cistern, and the rainwater that it stores, embodies joy, faith, and prosperity. In 2009, P1MC received a prestigious SEED award for entrepreneurship in sustainable development in recognition of the program’s social, environmental, and economic impacts for rural dwellers in NEB (SEED, 2009). Subsequently, in 2017, Program Cisterns was awarded the Future Policy Silver Award: Desertification by the World Future Council in partnership with the United Nations Convention to Combat Desertification (World Future Council,

⁷⁷ Original quote: “Mudou, foi uma riqueza para a gente ter água em casa da chuva. Antes era ruim. Tinha que pegar água nos açudes.” Interview: BE1DR0807B, 8/July/2022

⁷⁸ BR2cks0707B, 7/July/2022

⁷⁹ “Foi a melhor coisa que já fizeram” QM9JT2406A, 24/June/2022

⁸⁰ “Sem comparação” LA2D, 17/May/2022

n.d.). Despite the success of PIMC and the other programs, federal funding slowed to a trickle beginning in 2016, effectively halting cistern construction until the beginning of Lula's third presidential term in 2023.

Throughout the ongoing implementation of the programs, the mandatory water-resources-management training-course works to counteract NEB's historic dependence on patronage relationships to supply the rural poor with resources by preparing rural families to participate in a more democratic hydraulic citizenship. The process through which the cistern becomes part of a rural household decentralizes and democratizes water access, enacting a new hydraulic citizenship that challenges the legacies of clientelism and patronage in the hinterlands of NEB. While centralized water infrastructure remains at the forefront of mainstream policy debates in NEB and elsewhere, hydraulic citizenship is also performed through decentralized systems. In Brazil, the right to basic sanitation, which includes access to potable water, was established in 2007 and forms part of the promises and recognition of citizenship (Brazil, 2007b). In NEB, where it is generally infeasible to supply water to diffuse rural communities using centralized water infrastructure, modular, adaptive, and decentralized ("MAD") water models, including rain-harvesting cisterns, can be more effective to fulfill government promises of increased household water security through access to basic sanitation (Wutich et al., 2023). As part of Program Cisterns and other Brazilian cistern programs, specific trainings are carried out for rural beneficiaries, municipal commissions, and local bricklayers.

The government-sponsored cistern programs contribute to the formation of new hydraulic citizens through investing not only in the physical aspect of local water infrastructure—the cistern—but also through the water management course that program beneficiaries are required to participate in before receiving their cistern. In 2022, I participated in one of these two-day courses

with the 17 residents of Cachoeirinha, Quixeramobim, whose households would receive cisterns through the initiative led by IAC. The course followed the format of the PIMC and Program Cisterns capacity building courses, focusing on three overarching, fundamentally interrelated topics that promote *conscientização*, or the development of critical consciousness (Freire, 2000 [1970]): water resource management, citizenship, and “living with” the semi-arid region (ASA, n.d.a). Some of the key ideas emphasized in the training included the importance of rainwater harvesting to improving quality of life, that water is a right that should not be traded for goods or services, and that the cistern is *uma conquista* (a victory or achievement) that has been accomplished through the work of social movements and civil society (ASA, n.d.a).

Throughout the course, the facilitator—an Afro-Brazilian woman from a Quilombo community in the neighboring municipality of Quixadá—led us through participatory learning activities, accessible to all education levels, that situated concepts such as democracy, gender, and citizenship within the lived experience of the community. Participatory community mapping and a collective trash pick-up, for example, engaged directly with the physical and imaged geographic configuration of the community. Additionally, we explored the politics of productive and reproductive work and the persistence of gendered labor relations through the creation of men’s and women’s clocks (Figure 4.8). For this activity, the group split up by gender to divide the 24 hours of a day by the tasks typically carried out by their gender.⁸¹ After the presentation of the two clocks, the facilitator led the group through a discussion about the different activities typically ascribed to one gender or the other and how “men’s labor” is usually productive (i.e., produces

⁸¹ As a non-binary person who uses both they/them and she/her pronouns, I chose to present more femininely throughout my fieldwork and thus participated in the activity as part of the women’s group. The course facilitator acknowledged the multiplicity of genders and experiences at the beginning of the activity, recognizing that while individual experiences may not adhere to gender norms, traditional gender roles continue to play a significant role in society and especially in rural areas.

commodities and services) and located outside of the household, while “women’s labor” is reproductive in nature, sustaining the family in a cyclical fashion and located within the household.

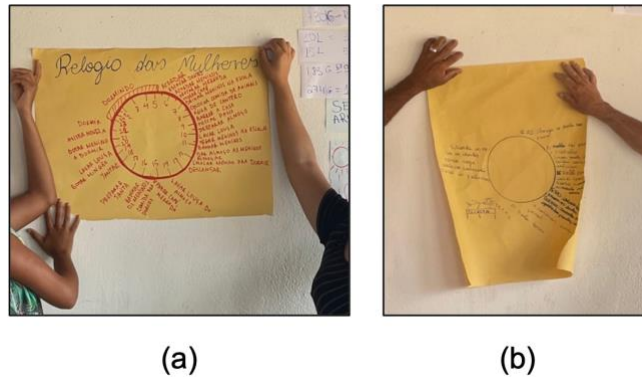


Figure 4.8 Cistern beneficiaries present the gendered labor clocks (*relógios de gênero*) developed collectively by the women (a) and men (b) participating in the cistern training course in Cachoeirinha, Quixeramobim, Ceará in April 2022. (Source: Author)

The training also addressed the clientelist relationships that have dominated the rural poor’s access to basic goods and services, including water, food, and healthcare. A short film, *Dona Caroba em Não troque sua voto pela água* (*Madam Caroba in Don’t Trade Your Vote for Water*), follows a local politician’s attempt to convince a community that it would receive cisterns thanks to him and as such, the community members would be indebted to him. The politician’s plan is ultimately thwarted by the film’s protagonist, Dona Caroba, a rural farmer who teaches her neighbors that the cisterns they receive are the result of grassroots struggles to ensure the rights, including the right to water, of all Brazilian citizens. The film addresses the oppressive client-patron relationships that have long characterized NEB using absurd humor with exaggerated local stereotypes, including the corrupt politician and ignorant farmer, and elicited many laughs from the audience in Cachoeirinha. Yet, through the laughter, the message of the film remained clear: water is a right for all and cannot be lost in an exchange for transitory goods or services. After the

film screening, the group facilitator led a group discussion, encouraging the participants to critically analyze the film's message and relate the situation to their own experiences.

Rural dwellers are required to participate in the water resources management training course to receive a cistern through the cistern-building programs. The two-day course forms part of the cistern as a social technology, using participatory learning methods to encourage the development of critical consciousness among program beneficiaries. In addition to learning how to care for their cistern, participants engage in group activities to explore topics including the semi-arid region, gender roles, and the importance of democratic participation in society. The course trains a new hydraulic citizen who understands water as not only a resource but also as a fundamental right. Oppressive patronage relationships are overtly criticized, and more just social arrangements are envisioned and realized.

4.6 Monitoring and Maintenance: Fluidity and Stagnancy

Once construction is completed, a cistern enters the monitoring and maintenance phase of the infrastructure lifecycle, during which the cistern is managed by the household who owns it. In this phase, cisterns become fully integrated into the daily lives of rural families and contribute to new modes of decentralized water service and delivery. Cisterns have greatly increased the sense of security of having access to potable water yearlong and the quality of the water consumed. The time spent retrieving water has decreased significantly with the arrival of the cistern. Rural families often expressed relief due to the reduced labor associated with obtaining water. Instead of daily trips to the distant cacimba or reservoir—a process that could often take hours—families retrieve water from a cistern two or three times a week, spending less than five minutes to visit the cistern and return inside. Cisterns also mediate new forms of water sharing between households;

participate in novel yearly rituals, such as cistern cleaning; and impact rural dwellers' interpretation of water and water quality. Social immobility is revealed through water treatment practices and the breakdown and repair of cisterns. To highlight the fluidity and stagnancy of rural hydraulic citizenship in NEB, I focus on cistern-related experiences of gender roles, water sharing, and (dis)repair, all associated with the monitoring and maintenance phase of the infrastructure lifecycle.

A gendered perspective highlights provides a more nuanced understanding of the dynamics of rural hydraulic citizenship for different genders. Water experiences are often differentiated by gender, as women are often household water managers and responsible for retrieving water from potentially distant sources (e.g., Sultana, 2011; Truelove, 2011). Yet, the distinction among gendered water experiences is not necessarily as concrete, particularly in urban contexts (Harris et al., 2017). In the rural zone of NEB, women and children have traditionally fetched water for household uses and women have acted as the primary household water managers, in charge of water-related (and reproductive) activities, including cooking, cleaning, clothes washing, and bathing children. In many households, the cistern has impacted who in the household carries out labor to obtain water. During interviews, many rural women explained that they prefer their husbands to fetch water from their cistern so that they themselves do not have to do this physical job. The shift in who is responsible for retrieving water appears to be due to at least two factors: children are required to go to school and thus participate less in water procurement and the cistern decreases the time burden of retrieving water, making it possible to carry out this task before or after work. Within the home, household, women have retained their roles as water management through reproductive household tasks.

In addition to impacting gendered water roles, cisterns enable different types of water sharing systems, connecting households within and between different rural communities and sometimes urban centers. Household water sharing in rural communities is often a coping mechanism for shortage of clean drinking water (Stevenson et al., 2012; Wutich et al., 2018). Before cisterns and community-level water systems became widespread across NEB, communal water was shared, as members of different households would travel daily to a collective water source to retrieve water for all uses. Cisterns have changed the dynamics of water sharing, as households now have their “own” water, which they may share with others. Through survey work, I found that families without a cistern normally obtained drinking water from a neighbor or family member who owned a cistern. The individualization of water access at the household level reflects the fact that each cistern built is registered under the name of an individual, and thus receiving a cistern provides a private means to access potable water yearlong.

However, in many cases, ownership of a particular cistern is blurred, particularly when residents of two or more houses share the water stored in the cisterns associated with each house. This most frequently occurred in moments when running water was unavailable, either because the houses never had running water or because the water running infrastructure of a community had collapsed. Many rural residents recounted participating in this type of negotiation during the 2012 – 2018 drought, when water trucks became the main source of water for household uses. They explained to me that while water-truck water was sufficient for household uses, they distrusted its quality for drinking. In Riacho da Cruz, a rural community in Quixeramobim, for example, a pair of neighboring houses would maintain one cistern with rainwater for drinking and cooking and delegate the other to store water-truck water for other household uses. In this example, the residents of the two houses were family—an elderly couple occupied one house, and their

daughter and her family (husband and two young children) occupied the other. As rural communities are often formed by one or two families that spread out across multiple houses, intra-family sharing is quite common and occurs between and among villages. However, water is not exclusively shared among family members but also among acquaintances and neighbors. As I would hear repeatedly in conversations with rural families, “You cannot deny water to anyone. Water is life.”

The dynamics of “decay, maintenance, and repair” (Ramakrishnan et al., 2020) over a cistern’s lifespan play an active role in water-sharing patterns and reveal tensions within rural hydraulic citizenship. Decay, maintenance, and repair highlight the “temporal fragility” of infrastructure and technological artifacts, including the cistern, and “[...] the labor enacted by ordinary people to secure connectivity and flows (Ramakrishnan et al., 2020, p. 676). In the communities I would visit, a broken hand pump and the appearance of small cracks or fissures in a cistern were common. Many people told me that their cistern’s pump broke within the first few months and that instead of fixing it, they would simply use a bucket to retrieve water from the cistern. This posed few problems, as many people prefer to use a bucket, even if their cistern pump functions, because the former is faster. A crack is a different story. In interviews, rural dwellers explained how, depending on its location and timing, a crack may be a nuisance or devastating: a cistern with a crack near the top may still be able to store sufficient water for a family, but when a crack is toward the middle or base of the structure that appears during the dry season, it becomes nearly impossible to retain any water at all. In the case of the latter, even with access to in-home running water, a family would rely on another household’s cisterns to obtain water for drinking and cooking, as in-housed piped water was typically not treated and unpotable.

Water sharing is a key strategy to cope with cistern decay in NEB, as repairing a cistern is often infeasible due to the character of the damage, the damage's timing, or the family's financial means. This is, in part, because the cistern programs do not provide support for maintenance, repair, or replacement and thus relegate the costs of these infrastructure phases to households. While small cracks visible from the outside of a cistern can be easily repaired with cement, larger fissures, particularly at the base of a cistern, have few practicable solutions. In these cases, the only way to once again harvest rainwater would be to raze and replace the cistern, which is financially inaccessible for most program beneficiaries, whose typical fixed income is a 600 BRL (150 USD) monthly cash benefit provided by the government.

In my conversations with rural families, no one mentioned ever trying to obtain funds for repair from government or non-government institutions. Rather, when possible, the family would mend the cistern, and when that did not work, they would leave the cistern in its damaged state. After attempting to repair his cistern several times, for example, a farmer from Posto Agropecuário explained that the cistern continued to leak, and he decided that it was easier to obtain water from a neighbor (personal correspondence, November 26, 2022). Once a cistern reaches a state beyond repair, it often becomes a vestige of past joy and present apathy. Families do not demand support from the government to maintain their right to water but rather seek rainwater from relatives or neighbors or, much less frequently, buy water for drinking and cooking. Hydraulic citizenship breaks down with the cistern's material decay. Rural dwellers' indifference to the government's lack of ongoing support throughout the infrastructure lifecycle questions the effectiveness of the capacity building workshops to train these citizens to demand and fight for their right to water. Fluidity and stagnancy characterize gendered water roles, the dynamics of water sharing, and cistern decay and (dis)repair, impacting rural hydraulic citizenship in diverse ways.

4.7 Cisterns and the Possible Futures of Rural Hydraulic Citizens

Rural hydraulic citizenship in NEB ebbs and flows throughout the infrastructure lifecycle of public cistern programs. The conception of the programs engendered great potential to improve water access, and thus to increase the hydraulic citizenship, of the rural poor. Yet, budgeting depends on the federal government and the priorities of the current government. The opposing priorities of Lula and Bolsonaro are reflected in the budgets for P1MC during their mandates and the number of cisterns constructed. Across NEB, hydraulic citizenship remained stagnant during Bolsonaro's mandate, as the budget for the construction of cisterns experienced extreme drought. The decision to use cement or polyethylene cisterns, as part of the design phase, also impacts rural citizenship differently, given the cisterns' different materialities and ability to hold water. Finally, while the capacity building course executed by the cistern program is meant to increase critical consciousness and (hydraulic) citizenship through greater recognition of basic rights, the course's effectiveness is put into doubt by the ways rural dwellers cope with the breakdown of their cistern during the monitoring and maintenance phase. The ways rural families negotiate the final stage of the infrastructure lifecycle—the choice to depend on local social networks when a cistern breaks down rather than to manifest their needs to the government—put into question the sustainability of hydraulic citizenship across the infrastructure lifecycle of cistern programs.

Toward the end of writing this article, I received a WhatsApp video message from Gabriela, an interlocutor and now friend from the interior of Quixeramobim. With the pitter-patter of rainfall perceptible in the background, the video pans the view from her front porch until reaching her family's cistern, which was built the year before and is collecting rainwater for the first time. Delight filling her words, Gabriela says, "Hey friend, I'm here, just thinking about you. It [the cistern] is going to fill up soon! When it spills over, I'll tell you. Our grand sertão! It's going

to spill over soon, if God wills it. The rain is pretty good, right?” (personal correspondence, January 23, 2024).⁸²

When I met Gabriela and her family in 2022, they were experiencing one of the most precarious water situations I had encountered in the rural area of Quixeramobim: they did not have running water nor a cistern (either their own or a neighbor’s) from which to reliably obtain water. Rather, Gabriela would describe the stress and sense of agony she felt given her family’s dependence on private water trucks for water for all of their household needs, including drinking, cooking, cleaning, and bathing. This dependence stemmed, in part, from a lack of social relations with neighbors in order to retrieve cistern water—when the cistern of the one family they did have a stronger relationship with had dried out, Gabriela and her family were forced to drink poor quality water-truck water as they searched for an alternative. Isolated from water infrastructure in the region, they lacked any sense of hydraulic citizenship.

Since my first visit to Gabriela’s home, her family’s hydrosocial reality has transformed. Yet this has not occurred purely through the democratic ideals espoused by cistern programs. Before participating in the cistern program led by IAC and joyously celebrating her cistern’s construction, Gabriela achieved another victory: running water. Although the cistern program speaks against the clientelist relationships that undermine the rights of the rural poor, Gabriela, like other rural dwellers, recognizes her entanglement in patronage relationships. Motivated by her frustration with the local water authority’s irresponsiveness to her demands for running water, which was already installed in other parts of her community, Gabriela leveraged her voting power, “playing the game,” as she phrased it, in order to gain the support of the Municipal Secretary of

⁸² Original quote: “Eita amiga, tô aqui só me lembrando de você. Vai já encher. Quando estiver sangrando, eu lhe digo. Sertãozinho. Já vai sangrar, se Deus quiser, chuvinha até boa, viu.”

Agriculture and Water Resources to work with the local water authority to install running water in her home (personal correspondence, April 16, 2023).⁸³ While her vote for mayor will remain secret by law in the upcoming 2024 elections, Gabriela suggested that by helping her obtain and install the pipes needed to connect to the municipal water system, the Secretary of Agriculture and Water Resources and his candidate for mayor would gain her support during the election cycle. Gabriela's hydraulic citizenship encompasses her family's access to running water and her cistern. The ways in which she has negotiated this citizenship within the local decentralized water infrastructure evokes the clientelist relationships that once dominated the sertão as well as the social technology principles of democracy and liberation espoused by ASA and the cistern programs.

Gabriela's experience illustrates how, over the past two decades, cisterns as a social technology have fundamentally changed many hydrosocial relations while the legacies of oppressive client-patron relations continue to seep into contemporary water struggles. The household cistern embodies the concepts of "living with" the semi-arid region and aspirations toward social transformation and liberation. However, public cistern programs still do not contemplate the latter stages of the infrastructure lifecycle—including maintenance, repair, and decommission. At the same time, in many cases, rural dwellers have yet to fully grasp the meaning of their right to water despite capacity building courses aimed at raising their awareness of this right. These realities expose some of the limitations of citizen formation through social technologies. Rather than hold their government accountable for repair and cistern decommission or replacement, rural households rely on neighbors and family members for access to potable water when a cistern breaks. Transformations in the cistern programs are required to uphold rural

⁸³ Municipal secretariats and the municipal water authority are under the auspices of the *prefeitura*, or mayor's office. As such, municipal secretaries and the president of the water authority are appointed by the mayor and act as extensions of the mayor's office.

hydraulic citizenship during the latter stages of the programs' infrastructure lifecycle. Yet for these transformations to occur, rural dwellers in the hinterlands of NEB must also further develop their sense of hydraulic citizenship and demand the rights promised by their government.

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CHAPTER 5

INTEGRATIVE METHODS TOWARD MORE JUST WATER FUTURES

5.1 Introduction

Water is a transdisciplinary medium. It is integral to the universal human experience, yet the diverse ways people relate to water reflect particular socionatural configurations. As Farhana Sultana (2018, p. 484) observes, water “[...] seeps across all boundaries and all aspects of life, as it is simultaneously social, economic, political, institutional, cultural, spiritual and ecological.” In this dissertation, I employ theory and methods from disparate areas of study—theatre and performance, hydrology, anthropology, and philosophy of technology (PhilTech)—to examine human-water relations in the semi-arid region of Ceará, Northeast Brazil. Each chapter engages with the embodiment of one or more aspects of the relational framework presented in Chapter 1, which situates the lived experience of water insecurity as an emergent property of the interactions among sociopolitical relations, cultural values, technological relations, and environmental processes. Embodiment acts as a boundary object to facilitate the integration of the diverse ways of knowing presented in the chapters to create more holistic understandings of the chronic water insecurities and inequities in Ceará. As a researcher from the United States, I was welcomed into the homes of families across Sertão Central and continually reflect on how my positionality impacts my role as researcher, colleague, friend, and family in Ceará. As water-related challenges continue to evolve in Quixeramobim and across semi-arid regions globally, greater attention to the recursive relationships between intertwining socionatural dynamics and the lived experience of

water insecurity of traditionally marginalized groups, including the rural poor, is essential to create more just water futures.

5.2 Embodiment as a Boundary Object in Integrative Water Research

By establishing the body as the mediator of experience, the concept of embodiment is suitable to examine both the lived experience of water insecurity and the larger socionatural relations through which this experience emerges. However, the term is deployed in different, yet overlapping, ways across the fields of anthropology, PhilTech, and performance studies. Like other boundary objects, the concept of embodiment permits different groups to work together without consensus, in part due to the term's interpretive flexibility (Star, 2010; Star and Griesemer, 1989). Residing in a nebulous form among the fields of anthropology, PhilTech, and performance studies, the concept of embodiment becomes more defined and more tailored to the particular field of study by the scholars who make up that community of practice. Although Star (2010, p. 605) argues that the *modus operandi* of boundary objects makes these objects useful for work that is not interdisciplinary, integrative research requires recognition of the boundary-object nature of terms and concepts that are consistently used in different areas of study.

In anthropology, “the body” refers the human body, and the embodiment of water insecurity is often discussed in terms of water-related suffering, that is, negative bodily sensations related to lack of adequate access to safe, quality water (e.g., Ennis-McMillan, 2001). Chapter 4 activates this definition of embodiment, drawing on the data from my ethnographic research—including my visits with Gabriela, the households in Tunísia, and the community members of Quilombo Mearim—and the data from my household water insecurity survey research to describe the embodied experiences of differential access to water in the past and present. The changes in

water harvesting practices in Quilombo Mearim and in the stress related to lack of reliable water access by Gabriela exemplify this approach. The labor once carried out daily, primarily by the women of Quilombo Mearim, to retrieve water from the communal *cacimbão* (a large, shallow well) is an example of the embodied experience of not having access to quality water inside one's home. Federal cistern programs, as well as public programs to install in-home running water, increased access to quality water and decreased the embodied experience of water insecurity for the households of Quilombo Mearim. Gabriela experienced similar transformations in her lived experience of water (in)security between when I met her in 2022 and when I wrote my dissertation in 2023 and 2024. Until 2023, Gabriela did not have access to running water or potable rainwater for drinking and cooking. The joy she expressed in the video messages she sent me via WhatsApp to update me on the rainfall her cistern was collecting is an embodied experience of greater water security. How Gabriela negotiated her hydraulic citizenship to increase her family's access to water is another example of her embodiment of her family's water insecurity in the particular sociopolitical and ecological contexts of Ceará.

The concept of embodiment is employed within PhilTech to examine human-technology relations and the expression of social and political values through technological devices. In Chapter 3, for example, the use of minipans to measure evaporation resulted in new hermeneutic relationships between the researcher (me) and the Cachoeira do Germano and São Miguel Reservoirs. These relationships were mediated by the minipan, as well as by the mass balance used to measure how much water was lost from the pans and the apparatuses used to measure environmental conditions. In Chapter 4, I build on other PhilTech understandings of embodiment, arguing that public cistern programs in Northeast Brazil and the cistern itself embody the values of the Social Technology movement in Brazil adapted to the socionatural processes that shape

water relations in Northeast Brazil. The chapter maps the ebbs and flows of rural hydraulic citizenship in Northeast Brazil onto the infrastructure lifecycle of public cisterns in order to illustrate the embodiment of Social Technology values—including community interaction, community empowerment, and social transformation—by the cistern programs and the materiality of the cement cistern. The chapter highlights the limitations of this form of embodiment to completely transform oppressive water relations through which rural poor continue to suffer and experience water insecurity.

Performance scholars deploy embodiment as theory and method to better understand how knowledge, culture, identity, and conflict become and are transmitted through performance. In Chapter 2, I show how *Water and Drought Dramaturgies* by Pavilhão da Magnólia and *The Drought Migrant* by Chico Oliveira and Débora Ingrid embody historical and contemporary water struggles in the Jaguaribe Valley of Ceará. The performance pieces contribute to contemporary Northeastern regionalist theatre through their “reactivation” (Sahakian, 2021, p. 346) of Northeast Brazilian imaginaries, such as the abjectly distressed drought migrant during periods of drought, along the shores of the Jaguaribe River. Both works embody the challenges of historically marginalized rural dwellers. However, Pavilhão da Magnólia draws more heavily from physical traces of the archive—including Rachel de Queiroz’s 1930 novel *O Quinze*, Northeast Brazilian regionalist paintings, newspaper archives, and climate data—whereas Chico and Débora use their own lived experience along the Jaguaribe River and the embodied memory transmitted by family members of past generations. My engagement with performance studies’ definitions of embodiment to analyze the cultural work of *Water and Drought Dramaturgies* and *The Drought Migrant* highlights how the performances confront the unequal social, political, and ecological relations that shape water inequities and water insecurity in Ceará.

Unlike in anthropology, PhilTech, and performance studies, embodiment is not a commonly used term in hydrology. In my dissertation, I extend the concept of embodiment to hydrological processes by acknowledging how the dynamics of bodies of water are influenced by social, political, and ecological relations. As mentioned in Chapter 1, large-scale water infrastructure projects, including the construction of large-scale reservoirs and water transportation systems, are key responses by the State of Ceará to drought and water security issues. In Chapter 2, I discuss how *Water and Drought Dramaturgies* and *The Drought Migrant* perform changes in the Jaguaribe River's flow, changes caused by the interactions of climate conditions, policy decisions, water values, and water uses in the region. The absence of water during times of drought in the past and present has led to water-related suffering of the rural poor, who depend on that water primarily for household uses and animal husbandry. On the other hand, actions by the State to prioritize the water supply of Fortaleza and large-scale irrigation projects result in changes of the river's flow, as water is diverted from the Jaguaribe River to the open canal system through which it travels to Fortaleza and as the water that remains in the Jaguaribe River is extracted for irrigation. The Jaguaribe River is a perennialized river whose flow, classically understood as a hydrological process, embodies intertwining social and natural relationships.

While not directly referenced in Chapter 3, embodiment also frames the evaporation studies presented in that chapter. Evaporation from open water sources, including the Cachoeira do Germano and São Miguel Reservoirs studied in Chapter 3, can be understood to be a function of climatic factors, such as radiation, wind speed, air temperature, water temperature, and humidity. At the same time, evaporation is a factor of the presence of the body of water itself and its surface area, both of which are the result of value-laden political decisions. The use of reservoirs to guarantee water supply across Ceará reflects the limited groundwater resources in much of the

state and the historic use of reservoirs to “solve” the drought problem throughout the 20th century. Understanding the evaporative demand of reservoirs is fundamental to assessing water availability, which directly impacts the lived experience of water insecurity. Chapters 2 and 3 illustrate that the term embodiment can be extended beyond its more traditional conceptualizations in anthropology, PhilTech, and performance studies to examine how hydrological processes and dynamics embody socionatural relations.

5.3 Situating Myself in my Research and Practice

As I employ embodiment to integrate understandings of water insecurity across diverse fields of study, I recognize that my perceptions and experiences are mediated through my own body. I chose to live in Quixeramobim during my two years of fieldwork in order to experience the everyday life I was studying. However, although I experienced water rationing, decreases in water quality, and a growing sense of unease as the Quixeramobim and Fogareiro Reservoirs dried up, I recognize that my lived experience in Quixeramobim varied greatly from other residents. As I mention in the introduction chapter, I am a white (Jewish) US-ian researcher. My socioeconomic position and the inherent respect I received from most people I met impacted how I navigated life in the interior of Ceará: I did not have to worry about everyday financial distress, and I had access to the people and resources I needed to carry out my research and take care of my daily needs.

In my work as anthropologist and performance artist, I recognize that my knowledge is always limited and that there will always be more to learn. Increased collaboration in ethnography is ever-important, as is the development of “openness, and care as livable realities” in anthropology based on lateral encounters, understood as “thinking and working side-by-side [...] with the critics, activists, public citizens, and cultural producers who enliven the local worlds we care about”

(Pandian, 2019, p. 14). Key to these lateral encounters is “coperformative witnessing,” participant observation that involves “[...] a riskier hermeneutics of experience, relocation, copresence, humility, and vulnerability [...]” (Conquergood, 2002, p. 19). Vulnerability, engagement, and solidarity were fundamental to my coperformative witnessing during my dissertation fieldwork and the communication of my research in the communities where I lived and worked.

While I arrived in Quixeramobim with a somewhat defined research plan, I engaged with local collaborators in order to shape my research to benefit the communities I would study. As I explain in Appendix 1, I collaborated with representatives from the Rural Workers Union, non-government organizations including IAC and IARTE, workers at the Municipal Secretariat of Health of Quixeramobim, the Landless Workers’ Movement (MST), and Paulo Ferreira from the Water Resources Management Company of Ceará (COGERH) to select the communities that would form part of the sample population for my household water insecurity survey research. In order to characterize water insecurity most accurately at the municipal level, a representative sample of communities was essential. My collaborators and I discussed different variables, including location, size, type (i.e., federal settlement, state settlement, community with association, community without association, or private farm), and main water source. Paulo Ferreira also helped me choose communities to do homestays in so that I could learn about the variety of water struggles in the region.

By working with local collaborators and contacting representatives from the communities where I wished to work, I sought to increase the procedural equity of my work. It was not perfect, as I already had somewhat defined research plans and goals, but I made sure local communities and other local collaborators participated in different planning steps. Before every community visit and survey application day, I confirmed with a community representative that I (and my research

assistants on the days they accompanied me) would be visiting the community. I asked for permission to visit and maintained transparency by explaining the motivations of our trips. By collaborating with local partners to choose communities where to work and maintaining open communication with representatives from the communities, I was able to select an appropriate sample of communities and show respect for the members of the communities I visited, as I worked to understand the diverse ways households in the rural area of Quixeramobim negotiate social, political, and ecological relations to improve their access to quality water.

My hydrology study also involved important collaborations with local partners at COGERH. I worked with the General Manager and Manager of Operations of COGERH to select two municipal reservoirs with local importance to carry out my evaporation study. Their technical and place-based knowledge afforded study sites with local significance such that the results of the study could have a positive impact on hydrological knowledge in the region. COGERH also supported the study by providing technical support during data collection days, which included assigning three technicians to help me, providing a boat, and loaning me measurement equipment. This support was fundamental to the success of the study. Because the technicians helped me design the floating rafts on which the minipans rested and helped me carry out the experiments, they will be co-authors on the article based on Chapter 4, which will be submitted to *Journal of Hydrology: Regional Studies*.

In addition to my research, I worked with local collaborators and colleagues at FUNCEME to improve water situations and increase water-related knowledge in Quixeramobim. For example, my survey work resulted in a database of the current hydrological situations of 52 communities in Quixeramobim. Before my work, such finely resolved data at the community level did not exist in a systematic way. I worked to expand this database to most, if not all, diffuse rural communities,

by surveying the municipal health agents that worked in the rural area. However, I was unable to create a fully comprehensive database due to the response rate of the health agents and time constraints. In addition to this work, I used my knowledge of local water issues to advocate for particular communities, which included speaking with the president of SAAE to understand why some communities lacked running water. I increased transparency between SAAE and impacted communities by sharing the information I learned from SAAE with community representatives. In addition, I worked with Nicolly Santos Leite at FUNCEME to fully characterize the water management of SAAE in the rural area of Quixeramobim. Nicolly and I interviewed all of the operators at SAAE in order to create a database of the different municipal water system networks in the rural area, which included the name of all of the communities that received water from each network, the number of houses connected in each community, the water source, and the treatment process. I shared the database with the president of SAAE, and he began to use it immediately to improve management strategies in the rural zone. My work contributed to recognition equity by making the diversity of lived realities of rural households more visible to authorities at the municipal level.

Throughout my fieldwork, one of my priorities was showing respect and kindness to the rural families who made my research possible. I did this throughout my fieldwork through everyday acts of care, including driving community members to Quixeramobim from their home in the rural area or back home from the urban center, picking up groceries or prescription medicine on my way to visit a family, washing and drying dishes (when families would let me), and helping to set up for birthdays and community celebrations. Through the intimacy of the quotidian, I became a member of several families in the interior of Quixeramobim and continue to feel connected through voice messages, quick texts, and virtual photo sharing.

In addition to these everyday moments, I organized and facilitated meetings in the communities where I carried out my survey research to share my research findings. During the second round of survey data collection (November 2022 – January 2023), I conversed with community leaders and research participants about organizing community meetings beginning in May 2023 to present the preliminary results and conclusions of my research. I received enthusiastic responses from the communities at that time. From May to August 2023, I conducted 35 meetings: 18 association meetings, 13 organized meetings, and four meetings that consisted of discussions with one to four individual families in a community. Out of the 52 communities, 15 communities did not have meetings due to scheduling conflicts or non-responsiveness by community contacts. Meeting logistics (i.e., day, time, and location) were scheduled based on the preferences of the communities. In order to increase attendance and decrease the number of meetings held in the community, many community leaders requested that I participate in their community association meeting, which is held monthly, every other month, or periodically, depending on the community. Through everyday acts of care and the community meetings to share my research, I worked to build meaningful relationships, based on respect, with the people who welcomed me into their homes and lives.

5.4 Potential Trajectories Toward Water (Security) Justice

It is fitting that I am writing this conclusion on March 19, *o Dia de São José*, the day of St. Joseph, the Patron Saint of the state of Ceará. Across Ceará, the day is filled with faith and anticipation: it is said that if it rains on *o Dia de São José*, it will be a good *inverno* (winter)⁸⁴ with

⁸⁴ While the Portuguese word “inverno” literally translates to “winter,” the term is used to refer to the rainy season across Ceará.

rains that bring abundance. Last year on this day, the Quixeramobim Reservoir was quickly recharging and building expectations that the reservoir would *sangrar* (spill over)⁸⁵ for the first time since August 2011. Two days beforehand, on March 17, 2023, I had accompanied technicians at SAAE in the reservoir, as they worked efficiently to remove the pipes, electrical cords, and other materials that had been installed to pump water from the cacimbão (now covered by water) used to supply water to Quixeramobim when the Reservoir had completely collapsed in December 2022 (Figure 5.1). The water from the cacimbão complemented water the city was receiving from the Fogareiro Reservoir, deep wells drilled throughout the city, and artisanal wells dug into the bed of the Quixeramobim Reservoir. At that time, the Fogareiro Reservoir was supplying about 70 percent of Quixeramobim’s water through an emergency pipeline. However, it was expected to dry up in May—and it would have had the heavy rains in March and April 2023 not arrived. The precarity of running out of water, the rapid transformation of the hydrological situation with the arrival of heavy rains, and the mediation of water relations through water technologies are endemic to life in Quixeramobim and across the semi-arid region of Ceará.

⁸⁵ The literal translation of the Portuguese word “sangrar” is “to bleed.” However, in Ceará, it is used to refer to the spilling over of different water storage technologies, including reservoirs, cisterns, and water tanks.



Figure 5.1 Preparing the Quixeramobim Reservoir for Water Supply Transitions.

Top: On December 8, 2022, technicians at SAAE install one of two cacimbões that were originally constructed in 2016, when the Quixeramobim Reservoir completely dried during prolonged drought. Bottom: SAAE technicians uninstall the cacimbão on March 17, 2023, as the Quixeramobim Reservoir begins to recharge after heavy rains in the region. (Source: Author)

Given the intimate interconnectedness of sociopolitical, hydrological, and technological factors to impact water realities, it is challenging—and perhaps unproductive—to attempt to analytically separate these variables in studies to understand experiences of water insecurity. As part of my continued scholarship on household water insecurity, I will be analyzing the two sets of survey data collected on the rainy season (collected May – July 2022) and on the dry season (collected November 2022 – January 2023) in the rural area of Quixeramobim. During the data collection, I observed that one of my basic assumptions—that I would be able to assess the impact of seasonality on water insecurity of all households by comparing the responses from the rainy and dry seasons—was flawed. This is because, in addition to changes in water supply, quality, and access between seasons, there can be complete transformations that are independent of seasonality. In Tunísia, for example, between my first round of data collection in May and my second round in November, four of the five families received a household rain-harvesting cistern and a deep well was drilled and installed in the community, providing a reliable water source for household uses.

As such, the families reported increased feelings of water security during the dry season compared to the rainy season due to factors unrelated to rainfall or the drying up of reservoirs over the course of the dry season. Part of my future work will be to quantitatively and qualitatively assess the dynamics of household water insecurity to understand the weighted effects of different factors, including seasonality, changes in household and community water infrastructure, inter-household relations, and relationships between households and political entities.

Trajectories toward greater water security and water justice require recognition of the interconnections among sociopolitical relations, cultural understandings and values of water, small and large water technologies, and environmental factors. Water justice is parity in experiences of access to quality water and water affect. Semi-arid regions, including Northeast Brazil, are experiencing more extreme climate conditions—with longer dry periods and fewer, but more intense, heavy rainfall events—a reality that will require integrative solutions that recognize inequitable experiences of prosperity and distress (Seigerman et al., 2024). Climate change and other socionatural processes are expected to intensify contemporary water crises and inequities globally, with the most marginalized suffering the worst outcomes (Sultana, 2018). It will therefore be ever important to consider the differential consequences of these processes, with particular attention to the experiences of traditionally marginalized populations, including the rural poor. Work toward water justice must include the dismantling of the intersecting relations of oppression—including race, gender, class, and Indigeneity—that result in inequitable experiences of water (in)security (Crenshaw, 1989; hooks, 2006; Nash, 2008, 2019). Water justice requires both valuing the lived realities, perspectives, and needs of marginalized groups and also the creation of new socionatural relations that afford liberation and thriving for all.

It rained in Quixeramobim and throughout Ceará on March 19, 2024.

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APPENDIX 1

HOUSEHOLD WATER INSECURITY SURVEY RESEARCH

A1.1 Introduction

Despite the known prevalence and detrimental consequences of water insecurity globally, comprehensive, cross-culturally validated scales to measure experiences of household or individual water insecurity have only recently been developed (Young et al., 2019). Household water insecurity metrics can provide an empirical basis from which to carry out longitudinal studies to assess changes in experiences related to water insecurity, defined as the inability to “access and benefit from affordable, adequate, reliable, and safe water” (Jepson et al., 2017, p. 3). Building on recent work by Tomaz et al. (2020) and Jepson et al. (2021) to develop a validated, regional tool to measure household water insecurity in the semi-arid region of Northeast Brazil, the current work assesses levels of household water insecurity in the rural zone of Quixeramobim, Ceará, Brazil using a mixed-methods household water insecurity questionnaire.

Based on ethnographic fieldwork in Quixeramobim, I adapted the multi-dimensional household water insecurity survey tool developed by Tomaz et al. (2020) to assess household water insecurity in the rural area of Quixeramobim. To be able to test impacts of seasonality, the survey was applied twice: at the end of the rainy season of 2022 (May – July 2022) and at the end of the dry season (November 2022 – January 2023), during which time a slightly modified version was used. The version used for the rainy season and the version used for the dry season are included (in Portuguese) in Appendices 2 and 3, respectively. The data collection protocol, including selection of potential communities, recruitment of communities and household, the survey versions

used, and data collection and storage methods were approved by the University of Georgia Institutional Review Board through the Office of Research (PROJECT00005299, “Household-Level Water Security in Ceará, northeast Brazil”).

In this appendix, I describe the survey tool, the sample selection, and data collection methods. I conclude with preliminary findings and future work. The survey research will provide a quantitative assessment of household water insecurity in the rural area of Quixeramobim to determine relationships among various variables, including water sources, seasonality, and food security. The quantitative analysis complements the ethnographic research carried out as part of this dissertation on the lived experience of water insecurity and on the sociopolitical and hydrological processes that affect water management in Ceará.

A1.2 Description of the Survey Tool

The mixed-methods questionnaire included quantitative and qualitative questions to characterize household demographics and to assess different dimension of water insecurity (i.e., water access, water quality, and water-related stress), household water uses, access to water-storage technologies (i.e., household cisterns and water tanks), and water sharing practices. Each participating household was asked about the sources of water they have access to and which sources the household uses for certain uses (i.e., drinking, cooking, brushing teeth, bathing, washing clothes, washing dishes, caring for animals, care for backyard crops, and other uses) during the rainy or dry season. For each use, the storage process was discussed. Of the sources that the family used, the two or three main sources for drinking, cooking and other uses were discussed further to understand how this water reaches the house, the months that the family uses this source, and the type of treatment, if any. For households with running water, the overall availability of

that water was characterized as continuous, predictably intermittent, irregularly intermittent, or unreliably intermittent. Furthermore, the money spent on obtaining drinking water and water for other uses was noted. Whether the household experienced water shortages and whether they had more than enough water. Parts 7, 8, and 9 used a frequency scale to assess water access, water quality, and water-related stress, respectively, over the past four months. These sections were followed by questions that use a frequency scale to measure household food security based on the Household Food Insecurity Access Scale (HFIAS) (Coates et al., 2007). During the first round of survey application, interviews ended with an open-ended question about the participant's experience in the community—their greatest challenges, what has changed over their lifetime, and anything else they wished to share. The responses were recorded with the permission of the participant. Most interviews lasted between 30 minutes and one hour.

A1.3 Survey Sample

The survey was applied with households across the rural zone of the municipality of Quixeramobim. One or more members of the household who were 18 years of age or older participated in the structured interview. A household ID was assigned to each participating household to decouple names from survey answers and protect the rights and welfare of participants. The sample size and distribution of surveys were based on the number of rural households reported in the 2010 census (IBGE, 2010) and a spatial analysis of household structures conducted by FUNCEME (Figure A1.1).

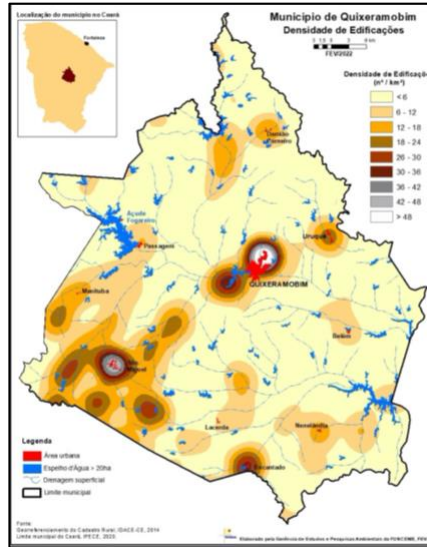


Figure A1.1 Density map of buildings in Quixeramobim (Source: FUNCEME, February 2022).

Following work by Tomaz (2019), the minimum sample size was calculated for a 90% confidence level with margin of error $\leq 5\%$ (Eq. A1.1).

$$n = \frac{Z^2 * p * q * N}{e^2(N - 1) + Z^2 * p * q} \quad (\text{Eq. A1.1})$$

Where n is the sample size, N is the population size, Z is the confidence level, p the population proportion, q is the complementary percentage to the population proportion, and e is the margin of error. To calculate n , the values listed in Table A1.1 were used. The minimum sample size was calculated to be 261 households.

Table A1.1 Values used to calculate minimum sample size.

Variable	Value
N	7735 households ^a
Z	1.645
p	0.5
q	0.5
e	0.05

^a Source: IBGE (2010)

Given time and logistic constraints, the sample distribution was determined using the rural population distribution at the district level (Table A1.2). The number of surveys to apply per

district was calculated using a study carried out by FUNCEME that identified the number of rural houses in Quixeramobim using satellite imagery. The minimum number of surveys per district was proportional to the percentage of houses identified in that district. A minimum of 265 total surveys was used rather than 261 to facilitate the calculation.

Table A1.2 Number of houses identified by satellite imagery and minimum number of surveys to conduct by district.

District	Houses Identified by Satellite Imagery ^a (% of total)	Minimum Number of Surveys
Manituba	1096 (25.7)	68
Quixeramobim	875 (20.5)	54
São Miguel	668 (15.7)	42
Passagem	392 (9.2)	24
Nenelândia	269 (6.3)	17
Damião Carneiro	235 (5.5)	15
Lacerda	209 (4.9)	13
Encantado	194 (4.6)	12
Uruquê	185 (4.3)	12
Belém	136 (3.2)	8
TOTAL	4259 (100)	265

^a Source: FUNCEME (February 2022)

After determining the initial distribution by district, I learned that another district, Berilândia, existed but had not been considered. To account for Berilândia, which was originally considered part of Nenelândia (an area with a lower density of houses), 12 surveys were assigned to Berilândia. This brought the total minimum surveys to be applied to 277 across the 11 districts (Figure A1.2, Table A1.3). Table A1.3 provides an overview of the number of communities selected per district and the number of surveys carried out per district during the first and second rounds of data collection. The number of communities to be surveyed per district was determined by assigning a minimum of four surveys per community. The minimum number of communities (two) were selected in Belém, Berilândia, and Encantado. The maximum number of communities (68) were selected in Manituba.

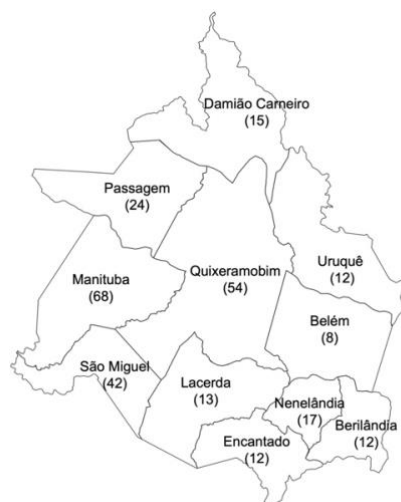


Figure A1.1 Minimum number of surveys to be completed per application by district.

Table A1.3 Number of surveys completed per district.

District	Minimum Number of Surveys to Complete	Number of Communities Surveyed	Number of Households Surveyed: 1 st Round (May – July 2022)	Number of Households Surveyed: 2 nd Round (November 2022 – January 2023)
Belém	8	2	17	17
Berilândia	12	2	13	12 ^a
Damião Carneiro	15	4	23	23
Encantado	12	2	13	13
Lacerda	13	4	25	25
Manituba	68	13	73	70 ^b
Nenelândia	12	4	27	24 ^c
Passagem	24	4	29	27 ^d
Quixeramobim	54	9	58	55 ^e
São Miguel	42	7	51	51
Uruquê	12	3	18	20 ^f
<i>Total</i>	<i>277</i>	<i>54</i>	<i>347</i>	<i>337</i>

^aTwo households that participated in the first round did not participate in the second round: one did not wish to participate, while the other household did not participate due to illness. One household participated in the second round but not the first round.

^bTwo households did not participate because they had moved away from the community.

^cTwo households did not participate because they had moved away from the community. One household did not participate due to illness.

^dOne household did not want to participate in the second round, while one household had moved away from the community.

^eThree households did not participate because they moved away from the community.

^fTwo households participated in the second round that did not participate in the first round.

Once the number of communities per district was determined, I worked with local collaborators to identify the communities in each district where the survey would be applied. A rural community was defined as two or more households located in the rural zone of Quixeramobim (as defined by legislation) that consider themselves a collective and identify themselves by common name. A comprehensive list of rural communities does not exist for the municipality of Quixeramobim. Additionally, while many rural communities with community associations are identified on the official municipal map of Quixeramobim, rural communities without associations are not.⁸⁶ As such, I identified possible communities using the municipal map of Quixeramobim and through conversations with collaborators from the Antônio Conselheiro Institute (IAC), the Rural Workers Union of Quixeramobim, the Institute of Art, Culture, Leisure, and Education (IARTE), the Landless Workers' Movement (MST), and the Quixeramobim Regional Office of the Water Resources Management Company of Ceará (COGERH).

Once I determined the list of possible communities, local collaborators provided contact information of a community representative, typically a community leader, community member, or the municipal health agent (*agente da saúde*) who worked with said community. I contacted the community representative via WhatsApp to explain the research, determine community interest, and obtain basic information about the community, including approximate number of people, approximate number of families, community organization, community water management regime, community water source (if applicable), and whether the community was located in a valley or in the highlands. Community organization refers to whether or not a community has an active

⁸⁶ The association is a legal entity recognized by the Federal Government. It is a form of representation for a community with respect to public authorities, companies, and other institutions. According to the Federal Law No. 11.127/2005, associations are formed by the union of people who organize themselves for non-economic purposes (Brazil, 2005). Associations must register with the National Register of Legal Entities (CNPJ) through the Federal Revenue Service and fulfill other organizational requirements outlined in Federal Law No. 11.127/2005.

association. Communities with associations include federal settlements, state settlements, and communities that are not settlements. Communities without associations include large farms (*fazendas*) and groups of families that consider themselves a community are not a legal entity registered with the National Register of Legal Entities (CNPJ). The list of federal settlements in Quixeramobim was obtained from the State Office of the National Institute for Colonization and Agricultural Reform (INCRA) located in Fortaleza. The list of state settlements in Quixeramobim was compiled with the help of collaborators at the Regional Office of MST in Quixeramobim. The communities that ultimately participated in the survey application were selected to create a representative sample of community characteristics based on number of families, community organization, community water management regime, and community water source, proportionally distributed across Quixeramobim by population density (Table A1.4, Figure A1.3). The names and exact coordinates of the communities are not included in this appendix as a way to protect the privacy of the communities and the participating households.

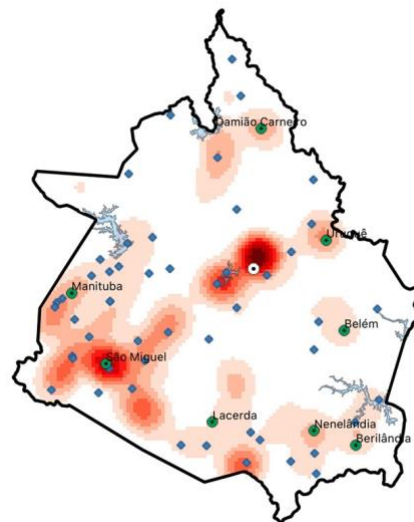


Figure A1.2 Location of communities in sample mapped onto building density map. (Elaborated by author)

Table A1.4 Characterization of the communities in the survey sample (N = 52).^a

District	Number of Families	Community Organization	Management Regime of Community Water System	Main Water Source for Community System	Located in Highlands or Valley
Belém (2)	≤ 10 (7)	Federal settlement (7)	Community (33)	Reservoir (27)	Highlands (23)
Berilândia (2)	11–20 (6)	State settlement (2)	SAAE (12)	Reservoir & well (3)	Valley (10)
Damião Carneiro (4)	21–30 (9)	Community with association (31)	No community system (4)	Deep well or cacimbão/river (19)	Highlands and valley (4)
Encantado (2)	31–40 (8)	Community without association (9)	Third party (3)	Carro pipa (3)	No information (15)
Lacerda (3)	41–50 (5)	Fazenda (3)	SISAR (0)		
Manituba (13)	51–60 (3)				
Nenelândia (4)	61–70 (1)				
Passagem (4)	71–80 (3)				
Quixeramobim (9)	81–90 (2)				
São Miguel (7)	91–100 (2)				
Uruquê (3)	110–150 (7)				

^a The number in parentheses indicates the number of communities in the sample.

In each community, participating households were selected using a random number generator that considered the total number of households (which was provided by the community contact) and the total number of surveys to apply. During the first round of data collection, if a household chose not to participate in the study, the neighboring household was selected. During the second round of data collection, if the original household chose not to participate or could not participate (due to illness or moving away from the community), another household was not selected to replace the original household. In a couple of instances, new households were surveyed in the second round and not the first round, due to showed interest and desire to participate by the members of those households.

A1.4 Data Collection

In order to probe relationships between dimensions of water insecurity and seasonality, structured interviews using the questionnaire were carried out with the same households twice: between May and July 2022 and between November 2022 and January 2023. During the first round of data collection, the minimum number of surveys were carried out in in given community on a single day, except in the case of Tunísia, where I returned on a second day to interview the fifth household. During the second round of data collection, there were sometimes multiple visits to a community in order to interview a participating family that was unavailable during the first visit.

During both rounds of data collection, paper questionnaires were used. Given variations in education level and rates of illiteracy across the sample population, researchers asked the participants each question verbally and recorded the participants' responses. The hand-written answers were subsequently transcribed by the researchers using a Qualtrics survey that matched the paper survey. The data inputted into the Qualtrics survey were downloaded as an Excel file and then verified to ensure that the inputs matched the original answers on the paper surveys. The recorded answers corresponding to last question of the first survey were transcribed using Sonix. All paper surveys were digitized and saved as pdfs. The raw survey data, recordings, recording transcriptions, and digitized paper surveys were stored using a protected Cloud service.

A1.5 Preliminary Findings and Future Work

The main objective of the application of the household water insecurity questionnaire is to better understand and characterize how water insecurity is experienced by rural dwellers in the municipality of Quixeramobim. In total, 347 households across 52 communities were interviewed during the first round of data collection and 337 households in the second round, with 334

households participating in both interviews. Based on the first round of data collection, the average household size in the sample was 3.36 members. A total of 29 (8.33%) of households had one member, while the maximum number of people in one household was 10. The majority of households surveyed had at least one household cistern (Table A1.5) and access to running water (Table A1.6).

Table A1.5 Number of cisterns per household.^a

Number of Cisterns ^b	Number of Households	% of total (N = 347)
0	65	19
1	252	73
2	28	8.0
3	2	0.57
4 or more	0	0

^a Data from first round of data collection was used.

^b A cistern was defined as a closed, fixed structure typically made of cement used to collect and store water (usually rainwater). Both drinking-water and production cisterns were included in this calculation. Portable and fixed water tanks (*caixas d'água*) and other water-storage devices were not considered cisterns in the study.

Table A1.6 Household access to running water by management type.^a

Running Water Management	Number of Households	% of total (N = 347)
No access to running water	31	9
Households with access to running water	316	91
<i>Community</i>	181	52
<i>Household</i>	30	8.6
<i>SAAE</i>	77	22
<i>Third party</i>	19	5.5
<i>Information not provided</i>	9	2.6

^a Data from first round of data collection was used.

Quantitative analyses will be carried out to quantify the experience of water insecurity across the dimensions of water access, water quality, and water-related stress and to statistically evaluate the relationship between the experience of water insecurity and variables at the household and community levels. Variables at the household level include inter and intra-household social relationships, access to water sources (for drinking, cooking, and other uses), water treatment

practices and preferences, water storage techniques, and access to public projects. Variables at the community level include community organization and cohesion, the community water management strategy, water sources (mainly for other uses), water treatment practices, and access to public projects.

Based on a preliminary qualitative assessment, at the household level, access to a rain-harvesting cistern, the use of a water tank, and access to running water are key determinants of household water security. At the community level, community structure and access to one or more reliable water sources stand out as key factors. In terms of water quality, both the physical characteristics of water and perceptions play important roles to determine households' satisfaction with the quality of their water. Within a given community, water access and water quality can vary greatly between households. However, across all households, a distinction is made between drinking water and water for other household uses. In general, running water is not potable, despite the use of simplified water treatment systems in some communities. As such, rainwater is the most commonly preferred source of drinking water. Most participants preferred rainwater over mineral water, citing quality and accessibility as the most important factors. For most households, buying mineral water to drink would only be considered out of desperation in a time of severe scarcity. The use of carro pipa water is also commonly associated with times of severe water scarcity. Across households, the experience of household water insecurity is relative and fluid, as it depends on lived experience and embodied memory of water access and quality, as well as factors related to climate, water technologies, and social dynamics. Over the last 25 years, the experience of water insecurity in the rural zone has improved greatly thanks to public projects, including projects to support the installation of electricity, running water, and household cisterns.

The quantitative assessment of the questionnaire responses will substantiate the understanding of the dynamics of water insecurity at the household level during the rainy and dry seasons. Statistical models will be built to test the relationship between household water insecurity and household and community-level factors for individual seasons. A third model will be built to compare seasonal impacts on water insecurity. The experience of water insecurity will also be tested against the experience of household food insecurity. In addition to improving knowledge on household water insecurity in the municipality of Quixeramobim, the analyses will contribute to global, cross-cultural household water insecurity studies through the Household Water Insecurity Experience (HWISE) Research Coordination Network. By increasing knowledge of experiences of household water insecurity in the semi-arid region of Ceará and how these experiences affect and are affected at the household and community levels, this work can inform initiatives to develop more sustainable and equitable water policies.

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APPENDIX 2

RAINY SEASON HOUSEHOLD WATER INSECURITY QUESTIONNAIRE

(APPLIED MAY 2022 – JULY 2022)

Insegurança Hídrica Domiciliar Ceará, Brasil	
Entrevistador _____	Data _____
Horário do início da entrevista _____	Horário do final da entrevista _____
ID Participante: _____	
Gênero de participante: (0) Masculino (1) Feminino (2) Outro _____	
Comunidade: _____	
Coordenados da casa: _____	
<p><i>O ID do participante deve começar com as seguintes letras do local do estudo:</i> Quixeramobim: Belém (BE), Berilândia (BA), Damião Carneiro (DC), Encantado (EN), Lacerda (LA), Manituba (MA), Nenelândia (NE), Passagem (PA), Quixeramobim (QM), Uruquê (UR)</p>	
<p>Introdução</p> <p>Estamos conduzindo uma pesquisa sobre a segurança da água da casa, ou a acessibilidade a água confiável e segura para uma boa vida. As informações que coletamos ajudarão os pesquisadores entender melhor os desafios e a situação das pessoas que moram na zona rural com a provisão de água para uso doméstico. O objetivo deste estudo é compreender os sistemas de água ao nível doméstico e avaliá-los em termos de segurança hídrica, definida como a água adequada, confiável e acessível para uma vida saudável. Esta pesquisa é conduzida por pesquisadores da Universidade de Geórgia em Estados Unidos, o Instituto Federal de Ceará (IFCE) e a Fundação Cearense de Meteorologia e Recursos Hídricos (FUNCEME).</p> <p>O(a) senhor(a) foi selecionado como possível participante da pesquisa porque vive numa das comunidades participando no estudo. Gostaria de lhe perguntar, como chefe de família ou adulto no agregado familiar, algumas questões sobre a provisão de água. Se concordar em participar do estudo, faremos perguntas durante 45-50 minutos. Realizamos partes desta pesquisa duas vezes, uma vez agora, durante o quadro chuvoso (o inverno) e mais uma vez na estação seca (o verão). Os riscos de participação são mínimos. Os participantes da pesquisa não serão pagos pela participação no estudo. Todas as respostas que o(a) senhor(a) fornecer serão confidenciais. Nenhum identificador que o/a ligue a este estudo será incluído em qualquer tipo de relatório que possa ser publicado. Em qualquer momento, o(a) senhor(a) pode decidir não contestar ou não continuar com a pesquisa.</p> <p>Este estudo será realizado com membros da sua comunidade, assim como de outras comunidades em Quixeramobim. Espera-se a participação de cerca de 300 famílias. Suas respostas podem nos ajudar a entender como as famílias da região usam e têm acesso à água, bem como as desigualdades relacionadas ao uso e acesso à água na região.</p> <p>O(a) senhor(a) gostaria de participar na pesquisa?</p> <p>O Sim O Não</p> <p>Se não: Obrigado pelo seu tempo.</p> <p>Se sim: A pesquisa esta dividida em várias partes. Primeiro, tem perguntas gerais sobre a família, com algumas perguntas sobre a renda mensal, porque precisamos entender os custos da água em relação ao agregado familiar. Depois, faremos um conjunto de perguntas sobre a fonte de água e armazenamento e sobre a sua cozinha doméstica e instalações de saneamento. O segundo conjunto de perguntas será sobre o acesso à água, seguido de perguntas sobre a qualidade da água e suas perspectivas sobre a água. Faremos 10 perguntas sobre o acesso ao alimento no domicílio, pois isso nos ajudará na nossa análise de dados.</p>	

1. Perguntas de triagem (5 itens)		
Primeiro, tenho algumas perguntas iniciais para o(a) senhor(a).		
Código	Pergunta	Resposta
SQ1	Qual é o nome do(a) senhor(a)?	
SQ2	O (a) senhor(a) tem 18 anos ou mais?	0 = Não 1 = Sim
SQ3	A. O (a) senhor(a) mora aqui, né? B. Quanto tempo o (a) senhor(a) mora nesta casa?	A. 0 = Não 1 = Sim B. _____ anos/meses
SQ4	O (a) senhor(a) se consideraria a pessoa que pode conversar sobre água dentro de sua casa? (aquisição, tratar, guardar...quem é responsável?) <i>Se "sim" continue com a segunda bloque. Se "não" continue com SQ5</i>	0 = Não 1 = Sim
SQ5	Se não, quem tem mais conhecimento sobre a aquisição e uso de água dentro de sua casa? Com quem devo falar?	

2. Perguntas Sócio-demográficas (4 itens)																																															
Agora, eu gostaria de saber mais um pouco sobre a família e quem mora na casa do(a) senhor(a).																																															
Código	Pergunta	Resposta																																													
SD1	O (A) senhor(a) é o chefe da família?	1 = Próprio chefe da família 2 = Cônjuge / Parceiro / Esposo/a 3 = Filho 4 = Outro _____																																													
SD2	Qual é o gênero do chefe de família (o(a) senhor(a))?	1 = Masculino 2 = Feminino 3 = Outro _____																																													
SD3	Quantos anos o chefe de família (o(a) senhor(a)) tem?																																														
SD4	Quantas pessoas em total moram na casa? _____ Quais são as idades e gêneros das pessoas que moram na casa? <i>Começa com o(a) entrevistado(a).</i>	<table border="1"> <thead> <tr> <th></th> <th>1</th> <th>2</th> <th>3</th> <th>4</th> <th>5</th> <th>6</th> <th>7</th> <th>8</th> <th>9</th> <th>10</th> <th>11</th> <th>12</th> <th>13</th> <th>14</th> </tr> </thead> <tbody> <tr> <td>G</td> <td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td> </tr> <tr> <td>I</td> <td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td> </tr> </tbody> </table>		1	2	3	4	5	6	7	8	9	10	11	12	13	14	G															I														
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SD5	Lista dos membros da família (para facilitar a conversa depois): A. A comunidade tem associação? Sim / Não B. <i>Se sim:</i> A família faz parte da associação comunitária? Sim / Não C. Se a comunidade é assentamento: A família é assentada ou agregada? Assentada / Agregada / Outro _____																																														

3. Questões de renda e habitação (13 Itens)		
Agora, tenho umas perguntas sobre a renda da família e as condições da casa.		
RH1	Qual é a ocupação do(a) senhor(a)? E dos outros (e.g., <i>esposo, filhos</i>) na casa? Quais são as fontes de renda da casa? (<i>Se for aposentado(a), apontar e perguntar do que trabalhou anteriormente</i>)	
RH2	A família recebe algum benefício de transferência da renda do Governo Federal? (e.g., <i>Auxílio Brasil, Bolsa Família, Bolsa Maternidade, Auxílio-Gas</i>)	0 = Não 1 = Sim _____
RH3	Qual a renda mensal da casa aproximadamente? <i>Incluir benefícios como Auxílio Brasil.</i>	R\$ _____ / mês
RH5	O tamanho da área em uso produtivo (ha)?	
RH6	Quais atividades produtivas a família participa? (e.g., culturas, criar animais)?	
RH7	Quantos cômodos tem na casa?	
RH13	<i>Não tem que perguntar, só observar.</i> Qual é o material do revestimento?	1 = Alvenaria (tijolos/blocos) 2 = Taipa 3 = Madeira 4 = Papelão 5 = Outros _____
RH14	<i>Não tem que perguntar, só observar.</i> Qual é o material do telhado?	1 = Telha de cerâmica 2 = Amianto 3 = Metal corrugado 4 = Madeira 5 = Palha 6 = Outro _____ 7 = Telha de barro
RH9	Qual é a fonte de eletricidade?	1 = Rede (rede pública de eletricidade) Monofásico / Trifásico / Não sabe 2 = Solar 3 = Outros 4 = Nenhum
RH10	Que tipo de instalações sanitárias o (a) senhor(a) e os membros da sua família usam?	1 = Sistemas de canalização de esgotos 2 = Fossa séptica → ligada com esgoto 3 = Fossa séptica → não ligada com esgoto 4 = Balde 5 = Não sei / desconhecido 6 = Banheiros de compostagem 7 = Nenhum sistema; A céu aberto 8 = Outro _____
RH11	As instalações de saneamento são compartilhadas com outras pessoas?	1 = Uma família 2 = Duas famílias 3 = Entre 3 e 6 famílias 4 = Acesso público 5 = Não compartilhadas
RH12	Onde é que a família prepara a comida?	1 = Dentro da casa 2 = Fora / descoberto 3 = Fora / coberto
RH13	Qual é a condição da propriedade da casa?	1 = própria (quitada) 2 = própria (hipoteca/financiamento) 3 = aluguel 4 = Posse ilegal 5 = Compartilhado / família 6 = Cedida/emprestada 7 = Outros _____

4. Questões sobre cisternas domiciliais		
<i>No caso que observou uma cisterna na frente da casa: Eu vi que a família tem uma cisterna na frente da casa. Gostaria de saber mais um pouco sobre a cisterna. No caso que não observou uma cisterna, começa com CDI.</i>		
Código	Pergunta	Resposta
CD1	A família tem uma cisterna para água de beber? Tem mais de uma? <i>Se a família não tiver, continue com a próxima parte, "5. Abastecimento de água (WASH)"</i>	0 = Não Sim: quantidade = _____
CD2	Como a família conseguiu a cisterna? De um projeto ou a família construiu a cisterna com recursos próprios?	0 = Projeto: _____ (e.g., 1 Terra + 2 Águas, Dom Helder) 1 = Recursos próprios 2 = Outro _____
CD3	A cisterna foi construída em que ano? Se o(a) senhor(a) não lembra, a gente pode ir depois para ver o ano na placa da cisterna, certo?	0 = Ano: _____ 1 = Não sabe
CD5	Como a cisterna mudou o acesso à água da família? <i>Descrever mudanças do acesso, qualidade de água...</i>	
CD6	A cisterna funciona bem?	0=Não, 1 = Sim
CD7	A bomba funciona?	0=Não, 1 = Sim
CD8	Como se cuida da cisterna? Quantas vezes no ano se faz a limpeza?	
CD9	O(a) senhor(a) tem uma cisterna de produção (e.g., calçadão)? Se não, continue com "5. Abastecimento de água (WASH)."	0 = Não 2 = Enxurrada 1 = Calçadão 3 = Outro _____
CD10	Como o(a) senhor(a) conseguiu a cisterna de produção?	0 = Projeto: _____ (e.g., 1 Terra + 2 Águas, Dom Helder) 1 = Recursos próprios 2 = Outro _____
CD11	A cisterna foi construída em que ano?	0 = Ano: _____ 1 = Não sabe

5. Abastecimento de água (WASH)		
<i>Agora, eu gostaria de saber mais sobre como a família obtém água para as atividades domésticas.</i>		
	Pergunta	Resposta
F0	A casa tem água encanada? Quem é responsável pela gestão da água encanada?	0 = Não tem 1 = Sim, comunidade 2 = Sim, particular (a própria família) 3 = Sim, um terceiro 4 = Sim, SAAE 5 = Sim, Sisar 6 = Sim, não sabe 7 = Sim, outro _____
F1	Que fontes de água a família tem acesso? <i>Se o entrevistado responder "cisterna", note em "6. Armazenamento de água" e pergunte de onde vem a água na cisterna: a chuva, carro pipa?</i>	
F2	Qual o(a) senhor(a) prefere para beber?	
F3	Por que o(a) senhor prefere esta fonte?*	
F4	Qual o(a) senhor(a) prefere para outros usos?	
F5	Por que o(a) senhor prefere esta fonte?*	

*Respostas possíveis para F3 e F5

1 = odor/sabor/color 2 = quantidade disponível 3 = facilidade de acesso 4 = abastecimento constante

5 = preço 6 = abastecimento 7 = única opção 8 = água boa/potável 9 = Outro confiável

Agora eu vou listar vários usos de água. Para cada um, vamos repassar as fontes de água que a família usa. Se a família obtém água de múltiplas fontes, por favor, indique isso.

Para poços, note se o poço é da comunidade, particular, de um vizinho etc.

WASH 1	Usos	Fonte(s)
1 = Água encanada pública (e.g., da própria comunidade, SAAE, Sisar, Cagece) 2 = Canalizado do vizinho 3 = Chuva 4 = Açude 5 = Barreiro 6 = Riacho 7 = Rio 8 = Cacimba 9 = Cacimbão 10 = Carro pipa 11 = Poço de anel 12 = Poço profundo 13 = Chafariz 14 = Canal de irrigação 15 = Água de garrafão 16 = Outro _____	Beber	
	Cozinhar	
	Escovar os dentes	
	Tomar banho	
	Lavar roupa	
	Lavar louças	
	Cuidar animais no quintal (beber, limpeza)	
	Cultivos no quintal	
	Outro(s) uso(s)	

6. Armazenamento de água

Agora gostaria de saber sobre como a água na casa do(a) senhor(a) é armazenada **durante o quadro chuvoso (inverno)**. Vou repetir a lista dos usos de água dos que a gente falou agora e para cada um, gostaria que o (a) senhor(a) descrevesse como a água para esse uso é armazenada. O que é usado para guardar essa água?

WASH 2	Usos	Armazenamento <i>Descreve o processo.</i>
1 = Cisterna própria 2 = Cisterna de outra casa 3 = Caixa de água 4 = Tanque de pedra (sem tampa) 5 = Tambor (Balde com tampa) 6 = Balde (sem tampa) 7 = Garrafas reutilizadas 8 = Pote 9 = Outro _____	Beber <i>(se tem cisterna, pergunte se usa balde ou bomba para tirar água)</i>	
	Cozinhar	
	Escovar os dentes	
	Tomar banho	
	Lavar roupa	
	Lavar louças	
	Cuidar animais no quintal (beber, limpeza)	
	Cultivos no quintal	
	Outro(s) uso(s)	

WASH3A. Agora, vamos falar sobre a fonte de água que vocês preferem usar para beber/cozinhar durante o quadro chuvoso. **Fonte:**
Circule beber e/ou cozinhar, dependendo das respostas anteriores sobre as fontes de água usadas pelos usos.

WASH3Aa	Como a água para beber/cozinhar é transportada do ponto de acesso à casa? <i>Se a fonte de água for encanada (1), entregador (8) ou não aplicável (10), continue com WASH3Ad.</i>	1 = Água encanada em casa 6 = Animal 2 = Andando (a pé) 7 = Motocicleta/moto 3 = Bicicleta 8 = Entregador 4 = Carro 9 = Outro _____ 5 = Carrinho de mão 10 = Não aplicável																				
WASH3Ab	Quanto tempo (em minutos) leva para ir à fonte de água, obter água e voltar (incluindo o tempo de espera)?	_____ horas _____ minutos																				
WASH3Ac	Quantas viagens no total são feitas para este local por semana?	_____ idas e voltas ao local de pegar água																				
WASH3Ad	Quem é responsável por obter essa água para a casa?	1 = Membro(s) de família/casa: _____ <i>Usar números de página 2.</i> 2 = Entregador (alguém fora de casa)																				
Wash3Ae1	Num ano chuvoso, quais meses a família usa esta fonte?	<table border="1"> <tr> <td>1 Janeiro</td> <td>4 Abril</td> <td>7 Julho</td> <td>10 Outubro</td> </tr> <tr> <td>2 Fevereiro</td> <td>5 Maio</td> <td>8 Agosto</td> <td>11 Novembro</td> </tr> <tr> <td>3 Março</td> <td>6 Junho</td> <td>9 Setembro</td> <td>12 Dezembro</td> </tr> <tr> <td colspan="4">13 Todos os meses</td> </tr> </table>	1 Janeiro	4 Abril	7 Julho	10 Outubro	2 Fevereiro	5 Maio	8 Agosto	11 Novembro	3 Março	6 Junho	9 Setembro	12 Dezembro	13 Todos os meses							
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Wash3Ae2	Num ano com pouca chuva, quais meses a família usa esta fonte?	<table border="1"> <tr> <td>1 Janeiro</td> <td>4 Abril</td> <td>7 Julho</td> <td>10 Outubro</td> </tr> <tr> <td>2 Fevereiro</td> <td>5 Maio</td> <td>8 Agosto</td> <td>11 Novembro</td> </tr> <tr> <td>3 Março</td> <td>6 Junho</td> <td>9 Setembro</td> <td>12 Dezembro</td> </tr> <tr> <td colspan="4">13 Todos os meses</td> </tr> </table>	1 Janeiro	4 Abril	7 Julho	10 Outubro	2 Fevereiro	5 Maio	8 Agosto	11 Novembro	3 Março	6 Junho	9 Setembro	12 Dezembro	13 Todos os meses							
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WASH3Ag	Tratamento Depois de receber essa água em casa, vocês fazem alguma coisa antes de usar ela, um tipo de tratamento? Por exemplo, vocês coam a água ou botam cloro? <i>Se a água no é tratada, vá para a seguinte parte, WASH3B.</i> Na semana, vocês fazem isso sempre? Só às vezes, ou quando a água está suja. <i>Para cloro, escreve frequência em dias (e.g., cada 15 dias)</i>	<table border="1"> <thead> <tr> <th>Processo</th> <th>Frequência</th> </tr> </thead> <tbody> <tr> <td>0 = Não</td> <td></td> </tr> <tr> <td>1 = Ferver a água</td> <td></td> </tr> <tr> <td>2 = Usar de filtro (cerâmica, composto de areia)</td> <td></td> </tr> <tr> <td>3 = Filtra através de pano (tecido)</td> <td></td> </tr> <tr> <td>4 = Colocar cloro/ água sanitária na água</td> <td></td> </tr> <tr> <td>5 = Uso de moringa/lírio branco</td> <td></td> </tr> <tr> <td>6 = Coar a água</td> <td></td> </tr> <tr> <td>7 = Deixar a água parada</td> <td></td> </tr> <tr> <td>8 = Outro</td> <td></td> </tr> </tbody> </table> <p>Frequência: 1 = Nunca 2 = Só quando a água esta suja 3 = Às vezes 4 = Sempre 5 = Não sei</p>	Processo	Frequência	0 = Não		1 = Ferver a água		2 = Usar de filtro (cerâmica, composto de areia)		3 = Filtra através de pano (tecido)		4 = Colocar cloro/ água sanitária na água		5 = Uso de moringa/lírio branco		6 = Coar a água		7 = Deixar a água parada		8 = Outro	
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WASH3Ah	Quem trata a água?	1 = Indicar o(s) membro(s) da família: _____ 2 = Comunidade <i>Usar números de página 2.</i>																				
WASH3Ai	No mês passado, quanto dinheiro vocês gastaram para tratar a água?	R\$																				

WASH3B. Agora, vamos falar sobre a fonte de água que vocês usam para (beber / cozinhar / outros usos) durante o quadro chuvoso. Fonte:		Usos:																				
<i>Circule beber e/ou cozinhar, dependendo das respostas anteriores sobre as fontes de água usadas pelos usos.</i>																						
WASH3Ba	Como a água para beber/cozinhar é transportada do ponto de acesso à casa? <i>Se a fonte de água for encanada (1), entregador (8) ou não aplicável (10), continue com WASH3Bd.</i>	1 = Água encanada em casa 6 = Animal 2 = Andando (a pé) 7 = Motocicleta/moto 3 = Bicicleta 8 = Entregador 4 = Carro 9 = Outro _____ 5 = Carrinho de mão 10 = Não aplicável																				
WASH3Bb	Quanto tempo (em minutos) leva para ir à fonte de água, obter água e voltar (incluindo o tempo de espera)?	_____ horas _____ minutos																				
WASH3Bc	Quantas viagens no total são feitas para este local por semana?	_____ idas e voltas ao local de pegar água																				
WASH3Bd	Quem é responsável por obter essa água para a casa?	1 = Membro(s) de família/casa: _____ <i>Usar números de página 2.</i> 2 = Entregador (alguém fora de casa)																				
Wash3Be1	Num ano chuvoso, quais meses a família usa esta fonte?	<table border="1"> <tr> <td>1 Janeiro</td> <td>4 Abril</td> <td>7 Julho</td> <td>10 Outubro</td> </tr> <tr> <td>2 Fevereiro</td> <td>5 Maio</td> <td>8 Agosto</td> <td>11 Novembro</td> </tr> <tr> <td>3 Março</td> <td>6 Junho</td> <td>9 Setembro</td> <td>12 Dezembro</td> </tr> <tr> <td colspan="4">13 Todos os meses</td> </tr> </table>	1 Janeiro	4 Abril	7 Julho	10 Outubro	2 Fevereiro	5 Maio	8 Agosto	11 Novembro	3 Março	6 Junho	9 Setembro	12 Dezembro	13 Todos os meses							
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Wash3Be2	Num ano com pouca chuva, quais meses a família usa esta fonte?	<table border="1"> <tr> <td>1 Janeiro</td> <td>4 Abril</td> <td>7 Julho</td> <td>10 Outubro</td> </tr> <tr> <td>2 Fevereiro</td> <td>5 Maio</td> <td>8 Agosto</td> <td>11 Novembro</td> </tr> <tr> <td>3 Março</td> <td>6 Junho</td> <td>9 Setembro</td> <td>12 Dezembro</td> </tr> <tr> <td colspan="4">13 Todos os meses</td> </tr> </table>	1 Janeiro	4 Abril	7 Julho	10 Outubro	2 Fevereiro	5 Maio	8 Agosto	11 Novembro	3 Março	6 Junho	9 Setembro	12 Dezembro	13 Todos os meses							
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3 Março	6 Junho	9 Setembro	12 Dezembro																			
13 Todos os meses																						
WASH3Bg	<p>Tratamento Depois de receber essa água em casa, vocês fazem alguma coisa antes de usar ela, um tipo de tratamento? Por exemplo, vocês botam cloro ou fervem a água ou usam algum tipo de filtro?</p> <p><i>Se a água no é tratada, vá para a seguinte parte, WASH3C.</i></p> <p>Na semana, vocês fazem isso sempre? Só às vezes, ou quando a água está suja.</p> <p><i>Para cloro, escreve frequência em dias (e.g., cada 15 dias)</i></p>	<table border="1"> <thead> <tr> <th>Processo</th> <th>Frequência</th> </tr> </thead> <tbody> <tr> <td>0 = Não</td> <td></td> </tr> <tr> <td>1 = Ferver a água</td> <td></td> </tr> <tr> <td>2 = Usar de filtro (cerâmica, composto de areia)</td> <td></td> </tr> <tr> <td>3 = Filtra através de pano (tecido)</td> <td></td> </tr> <tr> <td>4 = Colocar cloro/ água sanitária na água</td> <td></td> </tr> <tr> <td>5 = Uso de moringa/lírio branco</td> <td></td> </tr> <tr> <td>6 = Coar a água</td> <td></td> </tr> <tr> <td>7 = Deixar a água parada</td> <td></td> </tr> <tr> <td>8 = Outro</td> <td></td> </tr> </tbody> </table> <p>Frequência: 1 = Nunca 2 = Só quando a água esta suja 3= Às vezes 4 = Sempre 5 = Não sei</p>	Processo	Frequência	0 = Não		1 = Ferver a água		2 = Usar de filtro (cerâmica, composto de areia)		3 = Filtra através de pano (tecido)		4 = Colocar cloro/ água sanitária na água		5 = Uso de moringa/lírio branco		6 = Coar a água		7 = Deixar a água parada		8 = Outro	
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WASH3Bh	Quem trata a água?	1 = Indicar o(s) membro(s) da família: _____ 2 = Comunidade <i>Usar números de página 2.</i>																				
WASH3Bi	No mês passado, quanto dinheiro vocês gastam para tratar a água?	R\$																				

6. Armazenamento de água

Agora, eu gostaria de fazer algumas perguntas sobre a quantidade de água que tem na casa.

Código	Pergunta	Resposta
WS5	<p><i>Se a casa recebe água encanada, faça a seguinte pergunta (ver nota embaixo). Se não continue com WS1.</i></p> <p>Em geral, caracterize sua disponibilidade de água encanada como: contínua, previsível, irregular ou não confiável.</p>	<p>1 = contínuo 2 = intermitência previsível 3 = intermitência irregular 4 = intermitência não confiável 5 = Não aplicável</p>

Contínuo: o abastecimento de água é **contínuo** com uma **pressão de água relativamente constante**.

Intermitência Previsível: oferta caracterizada por cortes de água que ocorrem geralmente dentro de um cronograma previsível e antecipado, e **com pressão de água relativamente constante** durante cada entrega. A programação pode ser em escalas de tempo de dias ou mais.

Intermitência Irregular: fornecimento intermitente chegando a intervalos desconhecidos dentro de curtos períodos de não mais de alguns dias. Os consumidores podem esperar receber uma certa quantidade de água dentro da unidade de tempo, embora eles não podem antecipar precisamente quando a água vai chegar. A **pressão da água pode ser inconsistente**.

Intermitência não confiável: oferta intermitente caracterizada por prazos de entrega incertos (e.g., risco de quantidade de água insuficiente, muitas vezes exacerbada por armazenamento limitado e longos períodos de não entrega). A entrega é inconsistente e a **pressão da água inconsistente** pode se manifestar como fonte não confiável.

WS1	<p>Aproximadamente quanto dinheiro foi gasto em obter água para sua casa (no último mês ou últimos dois meses)? <i>Pergunte sobre a água para beber e água para outros usos.</i></p> <p><i>Se a gente não souber a taxa de água encanada: Qual é a taxa de água? Tem que pagar se usar uma quantidade maior de água?</i></p>	<p>Beber: R\$ _____ / mês / 2 meses</p> <p>Outros Usos: R\$ _____ / mês / 2 meses</p> <p>Descreva aqui (taxa, etc.):</p>
WS2	<p>Durante este quadro chuvoso, a sua família experimentou escassez de água? Em quais meses? <i>Circule todos os meses.</i></p>	<p>1. Janeiro 2. Fevereiro 3. Março 4. Abril 5. Maio 6. Junho 13. Nenhum 14. Todos</p>
WS3	<p>Durante este quadro chuvoso, a sua casa teve água mais de suficiente? Em quais meses? <i>Circule todos os meses</i></p>	<p>1. Janeiro 2. Fevereiro 3. Março 4. Abril 5. Maio 6. Junho 13. Nenhum 14. Todos</p>
WS4	<p>Neste quadro chuvoso a sua família experimentou escassez de água tipicamente mais em algum período de dia? Por exemplo, pela manhã, à tarde?</p> <p>Teve um período no que vocês não tiveram acesso à água em casa?</p>	<p>1 = Manhã (Nascer do sol – 6h- às 11h59) 2 = Tarde (12h – 18h00) 3 = Noite (18h01 – 20h00) 4 = Noite até a madrugada (20h01 – 5h59) 5 = Nenhum 6 = Sempre</p>
WS6	<p>Agora, pensando num ano muito crítico, quando a sua família experimentasse falta de água, como a família conseguiu água? Qual foi o último ano que vocês experimentaram falta de água.</p>	<p>Ano: _____</p>
WS7	<p>Neste quadro chuvoso, houve momentos em que a chuva impediu o (a) senhor(a) ou alguém da família de realizar atividades particulares? Por exemplo, a chuva inundou a estrada e a família não conseguiu ir à cidade. Se não houve momentos este ano, qual foi o último ano em que isso aconteceu? O que aconteceu?</p>	<p>Ano: _____</p>

7. Escala de acesso à água doméstica

Agora, vou lhe perguntar mais sobre suas experiências com acesso à água na casa. Para cada uma das perguntas, indique quanto a situação aconteceu neste quadro chuvoso (neste inverno).

Entrevistador, marque a resposta que melhor corresponde à classificação de codificação. Se for “Sim”, use as frequências (e.g., 1-3 dias/mês, 2-4 dias/semana) para perguntar sobre a frequência.

Código	Pergunta e resposta
HWAS1a	Neste quadro chuvoso, a sua casa não teve água para beber (e cozinhar) em algum momento? Quantos dias aconteceu? [_____]
HWAS1b	Neste quadro chuvoso, houve dias em que a sua casa não teve água para outras atividades da casa, além de beber (e cozinhar)? Quantos dias isso aconteceu? [_____]
HWAS2a	Neste quadro chuvoso, o abastecimento de água da fonte de água principal para beber foi interrompido alguma vez? Quantos dias isso aconteceu? [___] Fonte: _____ <i>Referencie/confirme a fonte (cisterna, etc.) segundo as respostas anteriores.</i>
HWAS2b	Neste quadro chuvoso, o abastecimento de água da fonte de água principal para outros usos foi interrompido alguma vez? Quantos dias isso aconteceu? [___] Fonte: _____ <i>Referencie/confirme a fonte (água encanada, etc.) segundo as respostas anteriores.</i>
HWAS3	Neste quadro chuvoso, houve dias em que a sua família não teve água suficiente para o quintal, as culturas (cultivo) ou as árvores? Quantos dias? [_____]
HWAS4	Neste quadro chuvoso, houve dias em que não teve água suficiente para os animais no quintal? Quantos dias? [_____]
HWAS5	Neste quadro chuvoso, o tempo gasto na busca de água impediu o(a) senhor(a) ou alguém de sua casa de fazer outras atividades? Quantos dias isso aconteceu? [_____]
HWAS6	Neste quadro chuvoso, o tempo gasto na obtenção de água impediu o(a) senhor(a) ou alguém de sua casa de ganhar dinheiro (e.g., engajar-se em trabalho remunerado, atividades econômicas)? Quantos dias? [_____]
HWAS7	Neste quadro chuvoso, houve momentos quando o(a) senhor(a) ou alguém de sua família não tinha condições para comprar água (incluindo pagar combustível)? Quantos dias? [___]
HWAS8	Neste quadro chuvoso, o(a) senhor(a)s deixaram de comprar outras coisas ou de realizar um pagamento para guardar dinheiro de pagar água? Durante quantos dias? [_____]
HWAS9	Neste quadro chuvoso, houve momentos quando o(a) senhor(a) ou alguém da família quis comprar água, mas não havia lugar para comprar? Quantos dias aconteceu? [_____]
HWAS10	<i>Se tiver crianças na casa, pergunte. Se não, escreve 10 e siga com HWAS11.</i> Neste quadro chuvoso, o tempo gasto na obtenção de água impediu alguma vez o(a) senhor(a) ou alguém de sua família de cuidar de crianças em casa? Quantos dias isso aconteceu? [_____]
HWAS11	Neste quadro chuvoso, o tempo gasto na obtenção de água impediu o (a) senhor(a) ou alguém de sua casa de fazer tarefas domésticas (e.g., cozinhar, preparar alimentos, lavar roupa)? Quantos dias aconteceu? [_____]
HWAS12	<i>Se tiver crianças na casa, pergunte. Se não, escreve 10 e siga com HWAS13.</i> Neste quadro chuvoso, as crianças deixaram de ir à escola por falta de água? (e.g., por não poder tomar banho ou se alimentar; não tinha roupa limpa)? Quantos dias as crianças falaram? [_____]
HWAS13	Neste quadro chuvoso as limitações físicas impediram o(a) senhor(a) ou alguém da família de obter água? Quantos dias aconteceu isso? [_____]

0 Nunca	1 Raramente	2 Às vezes	3 Muitas vezes	4 Sempre	9 Não sei	10 Não aplicável
0 vezes	1-3 dias/mês	1-2 dias / semana	3-5 dias / semana	6-7 dias / semana	XX	XX

HWAS14	Neste quadro chuvoso, não houve água suficiente para lavar a roupa em algum momento? Quantos dias isso aconteceu? [_____]
HWAS15	Neste quadro chuvoso, o (a) senhor(a) ou alguém da sua família teve de mudar o consumo de alimentos porque não havia água suficiente (e.g., para lavar alimentos, cozinhar)? Quantos dias isso aconteceu? [_____]
HWAS16	Neste quadro chuvoso, o (a) senhor(a) ou alguém de sua família ficou sem lavar mãos depois de realizar atividades sujas (e.g., defecar ou trocar fraldas, limpar esterco de animais) por que não havia água suficiente? Quantos dias isso aconteceu? [_____]
HWAS17	<i>Se tiver crianças na casa, pergunte. Se não, escreva 10 e siga com HWAS18.</i> Neste quadro chuvoso, o (a) senhor(a) ou alguém de sua casa não teve água suficiente para lavar os rostos e mãos das crianças em sua casa? Quantos dias aconteceu? [_____]
HWAS18	Neste quadro chuvoso, o (a) senhor(a) ou alguém de sua família teve que ficar sem tomar banho (ou lavar o corpo) por que não havia água suficiente ? Quantos dias aconteceu? [_____]
HWAS19	Neste quadro chuvoso, o (a) senhor(a) ou alguém de sua família mudou a sua rotina por que teve que resolver um problema por conta da água? (<i>Dar exemplos: e.g., falta, mau cheiro, problemas dos serviços</i>) Quantos dias aconteceu? [_____]
HWAS20	Neste quadro chuvoso, os problemas com a água impediram o (a) senhor(a) ou outra pessoa na casa de participar de eventos sociais em sua comunidade (e.g., aniversários, igreja, funeral, reuniões comunitárias)? Quantos dias isso aconteceu? [_____]
HWAS21	Neste quadro chuvoso, o (a) senhor(a) ou alguém de sua família pediu água emprestada de outras pessoas? Quantos dias? [_____] <i>Se a resposta for nunca (0):</i> E no passado, isso aconteceu? Ou em outro ano? Frequência: [_____] Ano: [_____] <i>Não sei (9) ou não aplicável (10):</i> vai para HWAS23. <i>Se a resposta for 1, 2, 3 ou 4, continue com HWAS22a-d.</i>
HWAS22a	De quem vocês pediram essa água? (e.g., vizinho, família, vendedor):
HWAS22b	Para que usos? 1 = Beber 3 = Cozinhar 5 = Lavar roupa 7 = Animais 9 = Outros 2 = Dentes 4 = Tomar banho 6 = Lavar louça 8 = Cultivos
HWAS22c	Que tipo de água foi? (e.g., de cisterna para beber, de cisterna de produção, água encanada...):
HWAS22d	Receberam a água suficiente? 0 = Não 1 = Sim
HWAS23a	Neste quadro chuvoso, o (a) senhor(a) ou alguém na sua família emprestou água para alguém? Quantos dias? [_____] <i>Se a resposta for nunca (0):</i> E no passado, isso aconteceu? Ou em outro ano? Frequência: [_____] Ano: _____ <i>Não sei (9) ou não aplicável (10):</i> continue com HWAS24. <i>Se sim,</i> continue com HWAS23b-c.
HWAS23b	Para quem vocês emprestaram água? (e.g., vizinho, família, vendedor):
HWAS23c	Que tipo de água foi? (e.g., de cisterna para beber, de cisterna de produção, água encanada...):

0 Nunca	1 Raramente	2 Às vezes	3 Muitas vezes	4 Sempre	9 Não sei	10 Não aplicável
0 vezes	1-3 dias/mês	1-2 dias / semana	3-5 dias / semana	6-7 dias / semana	XX	XX

HWAS24a	Neste quadro chuvoso, alguém (e.g., vizinhos, associações, a igreja) tem ajudado a garantir água? (e.g., dado garrafas com água, dinheiro para comprar)? Quantas vezes aconteceu? [_____]
HWAS24b	Neste quadro chuvoso, o(a) senhor(a) ou a comunidade participou num projeto relacionada com a água? Por exemplo, um programa de cisternas, perfuração de poço... 0 = Não 1 = Sim
HWAS24c	Que tipo de programa foi? Quem foi que organizou ou conseguiu o projeto?
HWAS25	Neste quadro chuvoso, passou dias nos quais não houve água suficiente para o (a) senhor(a) ou para os membros de sua família? Passaram quantos dias assim? [_____]
HWAS26	Neste quadro chuvoso, houve dias nos quais não houve tanta água para beber como o (a) senhor(a) gostaria para o (a) senhor(a) mesmo ou alguém em sua casa? Quantos dias aconteceu? [_____]
HWAS27	Neste quadro chuvoso, o (a) senhor(a) ou alguém de sua casa não teve água suficiente para tomar medicamentos ? Quantos dias aconteceu isso? [_____]
HWAS28	Neste quadro chuvoso, o (a) senhor(a) ou alguém de sua casa não conseguiu água onde queria porque estava muito doente ou fraco para conseguir água? Quantos dias aconteceu isso? [_____]
HWAS29	Neste quadro chuvoso, o (a) senhor(a) ou alguém da sua casa foi dormir com sede ? Quantos dias aconteceu isso? [_____]
HWAS30	Neste quadro chuvoso, houve dias em que não teve água (nada) em sua casa? Aconteceu quantos dias? [_____]

8. Escala da qualidade da água do agregado familiar

Agora vou perguntar sobre suas percepções da qualidade da água, tanto para beber (e cozinhar) como para os outros usos na casa.

Código	Pergunta e resposta
HWQS1	Neste quadro chuvoso, houve momentos quando a qualidade da água foi inaceitável para o consumo humano ? Ou seja, a família não bebeu essa água? Quantos dias aconteceu? [_____] <p><i>Se for nunca (0), não sei (9) ou não aplicável (10), continue com HWQS2. Se for 1, 2, 3, ou 4, continue com HWQS1b.</i></p>
HWQS1b	<i>Confirmar fonte:</i> Isso foi a água de que fonte? Por que a água foi inaceitável? O que vocês fizeram?
HWQS2	Neste quadro chuvoso, a qualidade da água foi inaceitável para uso em tarefas domésticas e limpeza ? Quantos dias aconteceu? [_____] <p><i>Se for nunca (0), não sei (9) ou não aplicável (10), vá pra HWQS3. Se for 1, 2, 3, ou 4, continue com HWQS2b.</i></p>
HWQS2b	<i>Confirmar fonte:</i> Isso foi a água de que fonte? Por que a água foi inaceitável? O que vocês fizeram?

0 Nunca	1 Raramente	2 Às vezes	3 Muitas vezes	4 Sempre	9 Não sei	10 Não aplicável
0 vezes	1-3 dias/mês	1-2 dias / semana	3-5 dias / semana	6-7 dias / semana	XX	XX

HWQS3	Neste quadro chuvoso, a qualidade da água foi inaceitável para uso em animais? Quantos dias aconteceu? [____] <i>Se for nunca (0), não sei (9) ou não aplicável (10), vá pra HWQS4. Se for 1, 2, 3, ou 4, continue com HWQS3b.</i>
HWQS3b	<i>Confirmar fonte:</i> Isso foi a água de que fonte? Por que a água foi inaceitável? O que vocês fizeram?
HWQS4	Neste quadro chuvoso, o (a) senhor(a) observou sujeira ou outros pequenos flutuadores na água? Quantos dias aconteceu? Beber: [____] Outros usos: [____]
HWQS5	Neste quadro chuvoso, o (a) senhor(a) sentiu mau cheiro ou forte cheiro vindo da água? Quantos dias aconteceu? Beber: [____] Outros usos: [____]
HWQS6	Neste quadro chuvoso, o (a) senhor(a) ou alguém de sua casa bebeu água que tinha um gosto ruim? Quantos dias aconteceu? [____]
HWQS7	Neste quadro chuvoso, o (a) senhor(a) notou que a água era de uma cor diferente ou turva? Quantos dias aconteceu? Beber: [____] Outros usos: [____]
HWQS8	Neste quadro chuvoso, o (a) senhor(a) queria tratar a sua água, mas não podia? Quantos dias aconteceu? Beber: [____] Outros usos: [____]
HWQS9	Neste quadro chuvoso, o (a) senhor(a) ou alguém de sua casa bebeu água que o (a) senhor(a) achava ruim? Quantos dias aconteceu? [____]

9. Escala do estresse por causa da água do agregado familiar				
Agora vou perguntar-lhe sobre o seu sentimento relacionado com o uso da água, o acesso, a qualidade no agregado familiar. Para as primeiras perguntas, vamos usar uma escala de 1 a 5, onde 1 é sem sentir preocupado ou incomodado, e 5 é estar muito, muito preocupado?				
1	2	3	4	5
Sem preocupação	Incomodado	Preocupado	Muito Preocupado	Muito muito preocupado
Código	Pergunta e resposta			
HWDS1a	Neste quadro chuvoso, (a) senhor(a) ou alguém de sua casa ficou preocupado(a) de que não teria água suficiente para beber? Quão preocupado(a)? [____]			
HWDS1b	Quantos dias se sentiu assim? [____]			
HWDS2a	Neste quadro chuvoso, o (a) senhor(a) ou alguém de sua casa ficou preocupado(a) de que não teria água suficiente para as outras necessidades domésticas? Quão preocupado(a)? [____]			
HWDS2b	Quantos dias se sentiu assim? [____]			
HWDS3a	O (a) senhor(a) ou alguém de sua casa ficou preocupado(a) sobre a segurança física em obter água para sua casa? Ao chegar, quero dizer: viajar para, recolhendo a água, e voltando com a água. Quão preocupado(a)? [____]			

0 Nunca 0 vezes	1 Raramente 1-3 dias/mês	2 Às vezes 1-2 dias / semana	3 Muitas vezes 3-5 dias / semana	4 Sempre 6-7 dias / semana	9 Não sei XX	10 Não aplicável XX
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HWDS3b	Quantos dias se sentiu assim? [_____]
HWDS4a	O (a) senhor(a) ou alguém de sua casa ficou preocupado de beber ou usar a água pela qualidade de água? [_____]
HWDS4b	Quantos dias se sentiu assim? [_____]
HWDS5	Neste quadro chuvoso, o(a) senhor(a) ou alguém de sua casa teve problemas com vizinhos devido à problemas com a água? Quantos dias isso aconteceu? [_____]
HWDS6	Neste quadro chuvoso, com que frequência o(a) senhor(a) ou alguém de sua família teve problemas com água que causaram dificuldades dentro de sua casa ? Quantos dias isso aconteceu? (e.g., brigas com familiares, desentendimentos) [_____]
HWDS7	Neste quadro chuvoso, o(a) senhor(a) ou alguém de sua família se sentiu muito preocupada quando não tinha água suficiente para as necessidades na casa? Quantos dias se sentiu assim? [_____]
HWDS8	Nas últimas quatro semanas, o(a) senhor(a) teve problemas com água que causaram dificuldades com o fornecedor ou vendedor de água ? Quantos dias isso aconteceu? [_____]
HWDS9	Neste quadro chuvoso, o (a) senhor(a) pensou alguma vez em deixar [nome da comunidade] por que não havia água aqui? Quantos dias pensou nisso? [_____]

10. Insegurança alimentar (10 Itens)	
<i>Agora eu vou perguntar sobre suas experiências com acesso a comida nas últimas quatro semanas. Vou perguntar-lhe sobre as frequências que o(a) senhor(a) experimentou algumas situações, e eu gostaria que o(a) senhor(a) me dissesse com que frequência tem acontecido nas últimas quatro semanas.</i>	
Código	Pergunta e resposta
FI1	Nas últimas 4 semanas, o(a) senhor(a) teve preocupação que a comida na sua casa acabasse antes que o(a) senhor(a) tivesse condições de comprar, receber ou produzir mais comida? Quantos dias? [_____]
FI2	Nas últimas 4 semanas, o (a) senhor(a) ou outra pessoa na sua casa deixou de comer suas comidas preferidas por falta de produção ou condições de comprar comida (dinheiro, transporte etc.)? Quantos dias? [_____]
FI3	Nas últimas 4 semanas, o(a) senhor(a) ou outra na casa teve que limitar a variedade de comidas por falta de produção ou condições de comprar comida? (e.g., dinheiro, negócios, terra ou qualquer outra coisa que o(a) senhor(a) precisaria para ajudá-lo a obter outros tipos de comida)? Quantos dias? [_____]
FI4	Nas últimas 4 semanas, o(a) senhor(a) ou algum membro da família teve que comer comidas que não queria por falta de produção ou condições de comprar comida? Quantos dias teve que fazer isso? [_____]
FI5	Nas últimas 4 semanas, teve que diminuir, alguma vez, a quantidade de alimentos nas refeições por que faltava comida em casa? Quantas vezes aconteceu? [_____]
FI6	Quantas refeições o(a) senhor(a) acha que deve comer em um dia? _____ refeições/dia
FI7	Nas últimas 4 semanas, com que frequência o(a) senhor(a) ou algum membro da família comia menos refeições porque não havia comida suficiente? Quantos dias aconteceu isso? [_____]
FI8	Já passou um tempo sem nenhum tipo de comida em casa porque não havia produção ou condições de comprar comida? Quantos dias aconteceu nas últimas 4 semanas? [_____]
FI9	Nas últimas 4 semanas, o(a) senhor(a) ou algum membro da família foi dormir à noite com fome porque não havia comida suficiente? Quantas noites aconteceu isso? [_____]
FI10	Nas últimas 4 semanas, o(a) senhor(a) ou algum membro da família se sentiu fome por um dia e uma noite inteiros devido à comida limitada na casa ? Quantas vezes aconteceu? [_____]

0 Nunca	1 Raramente	2 Às vezes	3 Muitas vezes	4 Sempre	9 Não sei	10 Não aplicável
0 vezes	1-3 dias/mês	1-2 dias / semana	3-5 dias / semana	6-7 dias / semana	XX	XX

Muito obrigado/a conversar comigo sobre estas temas. Agradeço muito. Para concluir, gostaria de perguntar o(a) senhor(a) o que o(a) senhor(a) acha da experiência de morar aqui. E quero pedir autorização de gravar a sua resposta. Do que da vida aqui o(a) senhor(a) gosta? Quais são as maiores dificuldades? Como a vida tem mudado nos últimos 10, 20, 30 anos? *Gravar e tomar notas.*

RH0	Puxa, agora fiquei curioso(a). Onde o(a) senhor(a) estudou? <i>Pergunte de curiosidade mesma.</i>	0 = Analfabeto 1 = Sabe ler e escrever 2 = Ensino Fundamental - até a 4ª série 3 = Ensino Fundamental - de 5ª a 8ª série 4 = Ensino Médio – Incompleto 5 = Ensino Médio – Completo 6 = Ensino Superior – Incompleto 7 = Ensino Superior – Completo 8 = Mestrado ou doutorado 9 = outro
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O(a) senhor(a) tem alguma pergunta para mim? Obrigado mais uma vez por participar desta pesquisa.

Qualidade dos dados: Para que o entrevistador completar <i>Dê sua avaliação sobre a qualidade e confiabilidade dos dados coletados nesta pesquisa.</i>		
DQ01	O entrevistado mostrou algum dos seguintes? (Marque todas as que se aplicam):	<input type="checkbox"/> Desconfiança de você ou do estudo <input type="checkbox"/> Desonestidade, mentir ou inventar respostas que não pareciam verdadeiras <input type="checkbox"/> Medo de você ou do estudo <input type="checkbox"/> Hostilidade, raiva ou ressentimento <input type="checkbox"/> Evasão ou tentando evitar responder
DQ02	Houve interrupções ou distrações?	0 = Não 1 = Sim, mas eu não acho que tenha influenciado as respostas 2 = Sim, e acho que isso influenciou as respostas
DQ03	Qual é a sua avaliação geral da qualidade dos dados nesta pesquisa?	0 = Excelente: O entrevistado entendeu o inquérito e esteve envolvido e não houve interrupções 1 = Tudo bem: O participante pode não ter entendido todo ou parte do inquérito bem ou houve algumas interrupções. 2 = Suspeito: O participante entendeu mal a pesquisa ou participou bem ou houve muitas interrupções.
DQ04	A qualidade dos dados desta entrevista é realmente importante para nós. Explique suas respostas acima, em termos de como os dados podem ter sido afetados. Há mais alguma coisa que precisamos saber?	

APPENDIX 3

DRY SEASON HOUSEHOLD WATER INSECURITY QUESTIONNAIRE

(APPLIED NOVEMBER 2022 – JANUARY 2023)

Insegurança Hídrica Domiciliar Ceará, Brasil	
Entrevistador _____	Data _____
Horário do início da entrevista _____	Horário do final da entrevista _____
ID Participante: _____	
Entrevistado no inverno: _____	
Gênero de participante: (0) Masculino (1) Feminino (2) Outro _____	
Comunidade: _____	
Coordenadas da casa: _____	
<p>Introdução</p> <p>Estamos realizando uma pesquisa sobre a segurança de água da casa, ou a acessibilidade a água confiável e segura para uma boa vida. As informações que coletamos ajudarão os pesquisadores a entender melhor os desafios e a situação das pessoas que moram na zona rural em relação à provisão de água para uso doméstico. O objetivo deste estudo é compreender os sistemas de água ao nível doméstico e avaliá-los em termos de segurança hídrica, definida como a água adequada, confiável e acessível para uma vida saudável. Esta pesquisa é conduzida por pesquisadores da Universidade de Geórgia em Estados Unidos, o Instituto Federal de Ceará (IFCE) e a Fundação Cearense de Meteorologia e Recursos Hídricos (FUNCEME).</p> <p>O(a) senhor(a) foi selecionado como possível participante da pesquisa porque vive numa das comunidades participando no estudo. Gostaria de lhe perguntar, como chefe de família ou adulto na família, algumas questões sobre a provisão de água. Se concordar em participar do estudo, faremos perguntas durante 45-50 minutos. Realizamos parte desta pesquisa na quadra chuvosa (o inverno). Agora, estamos realizando a segunda parte sobre a estação seca (o verão). Os riscos de participação são mínimos. Os participantes da pesquisa não serão pagos pela participação no estudo. Todas as respostas que o(a) senhor(a) fornecer serão confidenciais. Nenhuma informação que o identifique nesse estudo será incluída em qualquer tipo de relatório que possa ser publicado. A qualquer momento, o(a) senhor(a) pode decidir não responder a uma pergunta ou não continuar com a pesquisa.</p> <p>Este estudo está sendo realizado com membros da sua comunidade, assim como de outras comunidades em Quixeramobim. Mais de 300 famílias participaram na primeira parte. Suas respostas podem nos ajudar a entender como as famílias da região usam e têm acesso à água, bem como as desigualdades relacionadas ao uso e acesso à água na região.</p> <p>O(a) senhor(a) gostaria de participar na pesquisa?</p> <p>O Sim O Não</p> <p>Se não: Obrigado pelo seu tempo.</p> <p>Se sim: O questionário é muito semelhante ao anterior. Primeiro, há perguntas gerais sobre a família para revisar essas informações. Depois, faremos um conjunto de perguntas sobre as fontes de águas que a família usa no verão e o armazenamento dessas águas. O próximo conjunto de perguntas será sobre o acesso à água, seguido de perguntas sobre a qualidade da água e suas perspectivas sobre a água. Faremos 10 perguntas sobre o acesso ao alimento no domicílio, pois isso nos ajudará na nossa análise de dados. No final da conversa, revisaremos as condições da casa, porque essas informações nos ajudarão a entender as diferentes situações em todo o município.</p>	

1. Perguntas de triagem (5 itens)		
Primeiro, tenho algumas perguntas iniciais para o(a) senhor(a).		
Código	Pergunta	Resposta
SQ1	Qual é o nome do(a) senhor(a)?	
SQ2	Quantos anos o(a) senhor(a) tem? <i>Para participar na pesquisa, o entrevistado deve ter pelo menos 18 anos.</i>	Idade: _____
SQ3	A. O(a) senhor(a) mora nesta casa, né? B. Quanto tempo o(a) senhor(a) mora nesta casa?	A. 0 = Não 1 = Sim B. _____ anos / meses
SQ4	O(a) senhor(a) se consideraria a pessoa que pode conversar sobre água dentro de sua casa? (aquisição, tratar, guardar...quem é responsável?) <i>Se "sim" continue com o segundo bloco. Se "não" continue com SQ5</i>	0 = Não 1 = Sim
SQ5	<i>Se não:</i> Quem tem mais conhecimento sobre como a família obtém e usa água dentro de sua casa? Com quem devo falar?	

2. Perguntas Sociodemográficas (5 itens)																																															
Vamos revisar algumas informações sobre a família agora e outras no final da conversa. Essas informações são importantes para entender como a composição da família pode ser relacionada com o acesso e uso de água ao nível domiciliar.																																															
Código	Pergunta	Resposta																																													
SD1	Quem é o(a) chefe da família?	1 = Entrevistado é próprio chefe da família 2 = Cônjuge / Parceiro / Esposo(a) do entrevistado 3 = Mãe / pai do entrevistado 5 = Irmão / irmã do entrevistado 6 = Amigo do entrevistado 7 = Filho(a) do entrevistado 4 = Outro																																													
SD2	Qual é o gênero do(a) chefe da família?	0 = Masculino 1 = Feminino 2 = Outro _____																																													
SD3	Quantos anos o(a) chefe da família tem?																																														
SD4	Quantas pessoas no total moram na casa? _____ Quais são as idades e gêneros das pessoas que moram na casa? Essas informações são importantes para entender a relação entre a composição da família e a quantidade de água que a família usa. <i>Comece com o(a) entrevistado(a). Escreva "M" para masculino e "F" para feminino.</i>	<table border="1"> <thead> <tr> <th></th> <th>1</th> <th>2</th> <th>3</th> <th>4</th> <th>5</th> <th>6</th> <th>7</th> <th>8</th> <th>9</th> <th>10</th> <th>11</th> <th>12</th> <th>13</th> <th>14</th> </tr> </thead> <tbody> <tr> <td>G</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>I</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <i>Lista dos membros da família e/ou relações</i>		1	2	3	4	5	6	7	8	9	10	11	12	13	14	G															I														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14																																	
G																																															
I																																															
SD5	A. A comunidade tem associação? 0 = Não / 1 = Sim / 2 = Não sabe B. Alguém da sua família faz parte da associação comunitária ou da associação de outra comunidade? 0 = Não / 1 = Sim (da própria comunidade) / 2 = Sim (de outra comunidade) _____ C. <i>Se a comunidade é assentamento:</i> A sua família é assentada ou agregada? 1 = Assentada / 2 = Agregada / 3 = Outro _____ / NA (a comunidade não é assentamento) D. O(a) senhor(a) ou alguém da sua família faz parte do Sindicato de Trabalhadores Rurais? 0 = Não / 1 = Sim / 2 = Não sabe / 3 = Outro _____																																														

3A. Fontes de água (7 itens)		
Vamos conversar sobre diferentes fontes de água que a família usa e prefere. Para começar, gostaria de lhe perguntar sobre o inverno este ano. Depois, lhe perguntarei sobre a água encanada, o carro pipa e se a casa tem uma cisterna.		
Pergunta	Resposta	
Fi	O(a) senhor(a) acha que foi um bom inverno este ano? <i>(Teve muita fartura? [Não] fez água nos açudes? ...)</i>	0 = Não 1 = Sim 2 = Mais ou menos (regular) 3 = Outro _____
Fii	Por que ou por que não foi um bom inverno? <i>O que seria um bom inverno para o(a) senhor(a)?</i>	
F0a	A família tem água encanada (pública ou particular)? Quem é responsável pela gestão da água encanada? <i>Se não tem água encanada, escolha 0 e continue com a próxima parte. Se tem mais de um sistema, escolha as opções e descreva a situação.</i> 0 = Não tem 1 = Sim, comunidade 2 = Sim, particular (a própria família) 3 = Sim, um terceiro 4 = Sim, SAAE 5 = Sim, Sisar 6 = Sim, fazenda 7 = Sim, não sabe 8 = Sim, outro _____	Descrição:
F0b	<i>Se tem água encanada: Qual é a fonte da água para a água encanada? Pode escolher mais de uma opção. No caso, anote o responsável (F0a) para cada fonte.</i>	14 = Não sabe 6 = Riacho 10 = Carro pipa 3 = Chuva 7 = Rio 11 = Poço de anel 4 = Açude 8 = Cacimba 12 = Poço profundo 5 = Barreiro 9 = Cacimbão 13 = outro _____
F0c	<i>Se tem água encanada: A água encanada vai até dentro da casa (com/sem caixa d'água) ou só até a propriedade?</i>	1 = Dentro da casa (com caixa d'água) 2 = Dentro da casa (sem caixa d'água) 3 = Até a propriedade Descrição:
F0d	<i>Se tem a caixa d'água: A família tem que abrir/fechar a chave para encher a caixa?</i> Com que frequência?	0 = Não (tem uma boia) 1 = Sim NA = Não aplicável 2 = Não (outro motivo) NS = Não sabe 4 = Outro Frequência:
WS5	<i>Se a casa recebe água encanada: Em geral, caracterize sua disponibilidade de água encanada na torneira como: contínua, previsível, irregular ou não confiável. (Sempre tem água na torneira?)</i> <i>Ver a anotação para WS5 para caracterizar a disponibilidade.</i>	NA = Não aplicável, não tem água encanada 1 = contínuo 4 = intermitência não confiável 2 = intermitência previsível 5 = Gestão própria: por necessidade 3 = intermitência irregular 6 = Outro _____
WS6	<i>Se a casa recebe água encanada: O(a) senhor(a) sabe a frequência com que a água é liberada na rede? (Todo dia; um dia sim, um dia não...)</i>	NA = Não aplicável, não tem água encanada 1 = Todo dia 2 = Um dia sim, um dia não 3 = Não aplicável, própria gestão 4 = Outro _____ NS = Não sabe
WS5. Contínuo: o abastecimento de água é contínuo com uma pressão de água relativamente constante. Intermitência Previsível: oferta caracterizada por cortes de água que ocorrem geralmente dentro de um cronograma previsível e antecipado, e com pressão de água relativamente constante durante cada entrega. A programação pode ser em escalas de tempo de dias ou mais. Intermitência Irregular: fornecimento intermitente chegando a intervalos desconhecidos dentro de curtos períodos de não mais de alguns dias. Os consumidores podem esperar receber uma certa quantidade de água dentro da unidade de tempo, embora eles não podem antecipar precisamente quando a água vai chegar. A pressão da água pode ser inconsistente. Intermitência não confiável: oferta intermitente caracterizada por prazos de entrega incertos (e.g., risco de quantidade de água insuficiente, muitas vezes exacerbada por armazenamento limitado e longos períodos de não entrega). A entrega é inconsistente e a pressão da água inconsistente pode se manifestar como fonte não confiável.		

3B. Carro Pipa. (6 itens) Agora tenho algumas perguntas sobre o carro pipa.		
CP1	A família recebeu/usou carro pipa este ano? (2022)	0 = Não 1 = Sim 2 = Não sabe
CP6	Qual é a sua opinião sobre a qualidade da água de carro pipa? (<i>É boa para beber? Para outros gastos?</i>)	
CP2	<i>Se recebeu:</i> Em que meses o recebeu este ano?	1 2 3 4 5 6 7 8 9 10 11 12 13 = Todos os meses 0 = Nenhum mês 14 = Não sabe
CP3	<i>Se recebeu:</i> Com que frequência? (<i>Uma vez na semana, cada 15 dias, etc.</i>)	0 = Nunca 1 = 1 vez / mês 2 = cada 15 dias 3 = Outro _____
CP4	<i>Se recebeu:</i> Onde a água de carro pipa foi colocada? 1 = cisterna própria (1ª água) 2 = cisterna própria (2ª água) 3 = cisterna comunitária 4 = tanque próprio 5 = tanque comunitário 6 = Caixa d'água domiciliar 7 = Outro _____	
CP5	<i>Se recebeu:</i> Quem organizou o carro pipa para a família?	1 = Alguém da sua casa 2 = Presidente/líder da comunidade 3 = Defesa Civil 4 = Outro _____

3C. As cisternas domiciliais. (15 itens)			
Código	Pergunta e Resposta		
CD1	A casa tem uma cisterna? Quantas cisternas há no total? Isso é o número em total, tanto de primeira água quanto de segunda água. Um tanque de cimento com uma tampa também é considerado uma cisterna. 0 = Não tem Sim: quantidade = _____ <i>Se a casa não tem uma cisterna, continue com 3D (próxima página).</i>		
Para cada cisterna, vou lhe fazer algumas perguntas.		Cisterna 1	Cisterna 2
CD4	Para que vocês usam a água nesta cisterna?		
CD12	Que tipo de água está armazenada na cisterna agora? 0 = Chuva 1 = Carro pipa 2 = Chuva e pipa 3 = Outro 4 = Chuva e rede 5 = Rede 6 = Não sabe	0 1 2 4 5 6 3: _____	0 1 2 4 5 6 3: _____
CD2	Como a família conseguiu a cisterna? De um projeto ou a família construiu a cisterna com recursos próprios? 3 = Não sabe 0 = Projeto (<i>Qual é o nome do projeto?</i>) 1 = Recursos próprios 2 = Outro (<i>descreva</i>)	0: _____ 0: Não sabe qual 1: _____ 2: _____ 3: _____	0: _____ 0: Não sabe qual 1: _____ 2: _____ 3: _____
CD3	A cisterna é considerada: 1 = de primeira água ("cisterna de placa") Produção: 2 = calçada ou 3 = enxurrada 5 = de alvenaria 4 = outro	4: 1 2 3	4: 1 2 3
CD17	Quanta água ela armazena? V = volume NS = Não sabe	V: NS	V: NS
CD5	A cisterna foi construída em que ano?	Ano: NS	Ano: NS
CD6	A cisterna tem um vazamento ou outro problema? 0 = Não 1 = Sim (<i>descreva</i>)	0 1:	0 1:
CD13	A cisterna tem uma bomba? 0 = Não 1 = Sim, manual 2 = Sim, com motor 3 = Outro	0 1 2 3: _____	0 1 2 3: _____
CD7	<i>Se tem bomba:</i> a bomba funciona? 0 = Não 1 = Sim 2 = Não sabe	0 1 2	0 1 2
CD14	Como é que vocês tiram água da cisterna? (<i>Pode escolher mais de uma opção</i>) 0 = Bomba (manual) 1 = Bomba (motor) 2 = Puxa com motor para dentro da casa 3 = Balde 4 = Outro	0 1 2 3 4: _____	0 1 2 3 4: _____
CD16	Quando foi a última vez que ela foi lavada? (Mês e ano ou aproximação ou NUNCA) (<i>Se nunca foi lavada, continue com CD17</i>)		
CD15	Com que frequência vocês lavam a cisterna?		
CD17	Quando os canos foram desconectados (tirados) da cisterna este ano? (<i>mês ou descrição ou não foram tirados</i>)		

3D. Questões sobre cisternas domiciliais de outras casas (6 itens).			
Código	Pergunta/Resposta		
CD18	A família pega água da cisterna de outra casa? Não = 0 Sim = 1 <i>Se não: Continue com "4. Água suficiente?"</i> <i>Se sim: A família sempre pega água da mesma cisterna? Ou a família pega água de mais de uma cisterna? Anote o número de cisternas. _____</i>		
CD19	De quem é a cisterna? (Veja opções no final da seção.)	Cisterna 1 1 2 3 4 5 6 7:	Cisterna 2 1 2 3 4 5 6 7:
CD20	Por que vocês pegam água dessa cisterna?		
CD24	A cisterna é considerada: 1 = de primeira água ("cisterna de placa") Produção: 2 = calçadão ou 3 = enxurrada 5 = de alvenaria 4 = outro	4: 1 2 3 5	4: 1 2 3 5
CD21	Que tipo de água está armazenada na cisterna agora? 0 = Chuva 1 = Carro pipa 2 = Chuva e pipa 3 = Outro 4 = Chuva e rede 5 = Rede 6 = Não sabe	3: 0 1 2 4 5 6	3: 0 1 2 4 5 6
CD22	Como é que vocês tiram água da cisterna? (Pode colocar mais de uma opção) 0 = Bomba (manual) 1 = Bomba (motor) 2 = Puxa com motor para dentro da casa 3 = Balde 4 = Outro	4: 0 1 2 3	4: 0 1 2 3
CD23	Faz quanto tempo que a família pega água dessa cisterna? (meses e/ou anos)		

Códigos para CD18

1. Família (vizinha) 2. Família: mesma comunidade, não vizinha 3. Família: outra comunidade
4. Não familiar (vizinhos) 5. Não familiar: mesma comunidade, não vizinha 6. Não familiar: outra comunidade 7. Outro

4. Água suficiente? (3 itens)		
WS3	Durante os últimos quatro meses, a sua casa teve água suficiente? Em quais meses? <i>Circule todos os meses aplicáveis.</i>	7 8 9 10 11 12 0 = Nenhum
WS4	Nos últimos quatro meses, a família faltou água mais em algum período de dia? Por exemplo, pela manhã, à tarde? Teve um período no que vocês não tiveram acesso à água em casa?	1 = Manhã (Nascer do sol – 6h- às 11h59) 2 = Tarde (12h – 18h00) 3 = Noite (18h01 – 20h00) 4 = Noite até a madrugada (20h01 – 5h59) 5 = Nenhum 6 = Sempre

WASH1: Fontes. Primeiro, gostaria de saber a quais fontes a família tem acesso em verão. Depois, eu vou listar vários usos de água. Para cada um, vamos repassar as fontes de água que a família usou **nos últimos quatro meses (neste verão)**. Se a família obteve água de várias fontes, por favor, indique isso. *Para poços, note se o poço é da comunidade, particular, de um vizinho etc.*

WASH1i. Fontes. Este verão, a família tem acesso a quais fontes de água? (Se precisasse, a família poderia obter água de onde?) *Pode usar os códigos da lista de fontes embaixo.*

WASH 1	Usos	Fonte(s) usadas nos últimos 4 meses
1 = Rede de água encanada pública (e.g., da própria comunidade, SAAE, Sisar, Cagece) 2 = Canalizado do vizinho 3 = Chuva 4 = Açude 5 = Barreiro 6 = Riacho 7 = Rio 8 = Cacimba 9 = Cacimbão 10 = Carro pipa 11 = Poço de anel 12 = Poço profundo 13 = Chafariz 14 = Canal de irrigação 15 = Água de garrafão 17 = Reuso da água do esgoto 16 = Outro	Beber	
	Cozinhar	
	Escovar os dentes	
	Tomar banho	
	Lavar roupa	
	Lavar louças	
	Criar animais (beber, limpeza) [Fonte: Animal]	
	Cultivos no quintal	
	Outros usos (gastos)	

WASH2: Armazenamento de água.
 Agora gostaria de saber sobre como a água na casa do(a) senhor(a) é armazenada **durante os últimos quatro meses**. Vou repetir a lista dos usos de água dos quais a gente falou agora e, para cada um, gostaria que o(a) senhor(a) descrevesse o processo de como a água para esse uso é armazenada. O que é usado para guardar essa água?

WASH 2	Usos	Armazenamento <i>Descreve o processo.</i>
1 = Cisterna própria (primeira água) 2 = Cisterna de outra casa (primeira água) 3 = Caixa d'água 4 = Tanque de pedra (sem tampa) 5 = Tambor (Balde com tampa) 6 = Balde (sem tampa) 7 = Garrafas reutilizadas 8 = Pote 10 = Encanamento direito 11 = Cisterna própria (segunda água) 12 = Cisterna de outra casa (segunda água) 13 = Garrafões 14 = Filtro de barro 9 = Outro _____	Beber	
	Cozinhar	
	Escovar os dentes	
	Tomar banho	
	Lavar roupa	
	Lavar louças	
	Criar animais (beber, limpeza)	
	Cultivos no quintal	
	Outros usos (gastos)	

WASH3A. Agora, vamos falar sobre a fonte de água que vocês usam para beber no verão. Essa água também pode ser utilizada para cozinhar ou outros gastos.																						
Fonte:	Armazenamento inicial:	Usos: Beber / Cozinhar / Outros gastos																				
WASH3Ak	Por que sua família usa esta fonte de água para (<i>usos</i>) e as outras fontes, não?																					
WS1-3A	Aproximadamente quanto dinheiro foi gasto pela água em casa no último mês ?	R\$ _____ no mês ou ENERGIA (<i>paga apenas a energia que é incluído no gasto geral de energia para a casa</i>)																				
WASH3AI	A. Qual é a taxa de água? B. Tem que pagar se usar uma quantidade maior de água? Quanto paga?	A. Taxa: R\$ _____ / _____ L / mês ou 2 meses ou Outro: ou 0 = Não tem NS = não sabe B. 0 = Não ou Sim: R\$ _____ / _____ L ou NA																				
WASH3An	O(a) senhor(a) acha que a sua água é cara? Por quê?	0 = Não 1 = Sim NA = Não aplicável NS = Não sabe Justificação:																				
WASH3Aa	Como a água é transportada do ponto de acesso à casa? <i>O ponto de acesso pode ser a cisterna, o açude, o poço, etc.</i>	1 = Encanada em casa 4 = Carro 7 = Motocicleta/moto 2 = Andando (a pé) 5 = Carrinho de mão 8 = Entregador 3 = Bicicleta 6 = Animal 9 = Outro _____																				
WASH3Ad	Quem é responsável por obter essa água para a casa? (Levar a água para casa, ligar para o entregador, ligar/desligar motor, pagar a taxa). <i>Anote a responsabilidade de cada pessoa.</i>	Membro(s) da casa (gênero e idade): _____ Alguém fora de casa: Entregador / Família / Vizinho / Outro Responsabilidades:																				
WASH3Ab	Aproximadamente quanto tempo (em minutos) leva para ir à fonte de água, obter água e voltar (incluindo o tempo de espera)?	_____ horas _____ minutos NS = Não sabe NA = Não aplicável																				
WASH3Ac	Quantos dias na semana a família pega água da fonte? Quantas viagens são feitas por dia? <i>Se a água é entregue:</i> Quantos dias na semana (ou mês) o entregador a entrega?	Frequência de dias: Número de viagens por dia: Frequência: NS = Não sabe NA = Não aplicável																				
WASH3Ae	Este ano , em quais meses a sua família usou esta fonte?	1 2 3 4 5 6 7 8 9 10 11 12 13 = Todos os meses 0 = Nenhum mês																				
WASH3Ag	Tratamento Depois de receber essa água em casa, vocês fazem alguma coisa antes de usar ela, algum tipo de tratamento? Por exemplo, vocês coam a água ou botam cloro? <i>Se a água não é tratada, vá para WASH3B.</i> Quando vocês fazem esse tratamento? Com que frequência? 0 = Nunca 2 = Só quando a água esta suja 3 = Às vezes 4 = Sempre 5 = Não sabe 6 = Uma vez no ano 7 = Duas vezes no ano 8 = Outro (<i>descreva</i>) 9 = Apenas uma vez	<table border="1"> <thead> <tr> <th>Processo</th> <th>Frequência</th> </tr> </thead> <tbody> <tr> <td>0 = Não</td> <td>N/A</td> </tr> <tr> <td>1 = Ferver a água</td> <td></td> </tr> <tr> <td>2 = Usar filtro (cerâmica, composto de areia, barro)</td> <td></td> </tr> <tr> <td>3 = Filtrar através de pano (tecido) ("coar")</td> <td></td> </tr> <tr> <td>4 = Colocar cloro/ água sanitária na água</td> <td></td> </tr> <tr> <td>5 = Uso de moringa/lirio branco</td> <td></td> </tr> <tr> <td>7 = Deixar a água parada</td> <td></td> </tr> <tr> <td>9 = Colocar piaba (peixe)</td> <td></td> </tr> <tr> <td>8 = Outro</td> <td></td> </tr> </tbody> </table>	Processo	Frequência	0 = Não	N/A	1 = Ferver a água		2 = Usar filtro (cerâmica, composto de areia, barro)		3 = Filtrar através de pano (tecido) ("coar")		4 = Colocar cloro/ água sanitária na água		5 = Uso de moringa/lirio branco		7 = Deixar a água parada		9 = Colocar piaba (peixe)		8 = Outro	
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WASH3Aj	Por que a sua família (não) trata essa água?																					
WASH3Ah	Quem é responsável por tratar a água?	0 = Não tratada Membro(s) da família: _____																				
WASH3Ai	No mês passado , quanto dinheiro foi gasto para tratar a água? R\$ _____																					

WASH3B. Agora, vamos falar sobre a fonte de água que vocês usam para cozinhar e os outros gastos no verão.																						
Fonte:	Armazenamento inicial:	Usos: Beber / Cozinhar / Outros gastos																				
WASH3Bk	Por que sua família usa esta fonte de água para (<i>usos</i>) e as outras fontes, não?																					
WS1-3B	Aproximadamente quanto dinheiro foi gasto pela água em casa no último mês ?	R\$ _____ no mês ou ENERGIA (<i>paga apenas a energia que é incluído no gasto geral de energia para a casa</i>)																				
WASH3BI	A. Qual é a taxa de água? B. Tem que pagar se usar uma quantidade maior de água? Quanto paga?	A. Taxa: R\$ _____ / _____ L / mês ou 2 meses ou Outro: ou 0 = Não tem NS = não sabe B. 0 = Não ou Sim: R\$ _____ / _____ L ou NA																				
WASH3Bn	O(a) senhor(a) acha que a sua água é cara? Por quê?	0 = Não 1 = Sim NA = Não aplicável NS = Não sabe Justificação:																				
WASH3Ba	Como a água é transportada do ponto de acesso à casa? <i>O ponto de acesso pode ser a cisterna, o açude, o poço, etc.</i>	1 = Encanada em casa 4 = Carro 7 = Motocicleta/moto 2 = Andando (a pé) 5 = Carrinho de mão 8 = Entregador 3 = Bicicleta 6 = Animal 9 = Outro _____																				
WASH3Bd	Quem é responsável por obter essa água para a casa? (Levar a água para casa, ligar para o entregador, ligar/desligar motor, pagar a taxa). <i>Anote a responsabilidade de cada pessoa.</i>	Membro(s) da casa (gênero e idade): _____ Alguém fora de casa: Entregador / Família / Vizinho / Outro Responsabilidades:																				
WASH3Bb	Aproximadamente quanto tempo (em minutos) leva para ir à fonte de água, obter água e voltar (incluindo o tempo de espera)?	_____ horas _____ minutos NS = Não sabe NA = Não aplicável																				
WASH3Bc	Quantos dias na semana a família pega água da fonte? Quantas viagens são feitas por dia? <i>Se a água é entregue: Quantos dias na semana (ou mês) o entregador a entrega?</i>	Frequência de dias: Número de viagens por dia: Frequência: NS = Não sabe NA = Não aplicável																				
WASH3Be	Este ano , em quais meses a sua família usou esta fonte?	1 2 3 4 5 6 7 8 9 10 11 12 13 = Todos os meses 0 = Nenhum mês																				
WASH3Bg	Tratamento Depois de receber essa água em casa, vocês fazem alguma coisa antes de usar ela, algum tipo de tratamento? Por exemplo, vocês coam a água ou botam cloro? <i>Se a água não é tratada, vá para WASH3B.</i> Quando vocês fazem esse tratamento? Com que frequência? 0 = Nunca 2 = Só quando a água esta suja 3 = Às vezes 4 = Sempre 5 = Não sabe 6 = Uma vez no ano 7 = Duas vezes no ano 8 = Outro (<i>descreva</i>) 9 = Apenas uma vez	<table border="1"> <thead> <tr> <th>Processo</th> <th>Frequência</th> </tr> </thead> <tbody> <tr> <td>0 = Não</td> <td>N/A</td> </tr> <tr> <td>1 = Ferver a água</td> <td></td> </tr> <tr> <td>2 = Usar filtro (cerâmica, composto de areia, barro)</td> <td></td> </tr> <tr> <td>3 = Filtrar através de pano (tecido) ("coar")</td> <td></td> </tr> <tr> <td>4 = Colocar cloro/ água sanitária na água</td> <td></td> </tr> <tr> <td>5 = Uso de moringa/lírio branco</td> <td></td> </tr> <tr> <td>7 = Deixar a água parada</td> <td></td> </tr> <tr> <td>9 = Colocar piaba (peixe)</td> <td></td> </tr> <tr> <td>8 = Outro</td> <td></td> </tr> </tbody> </table>	Processo	Frequência	0 = Não	N/A	1 = Ferver a água		2 = Usar filtro (cerâmica, composto de areia, barro)		3 = Filtrar através de pano (tecido) ("coar")		4 = Colocar cloro/ água sanitária na água		5 = Uso de moringa/lírio branco		7 = Deixar a água parada		9 = Colocar piaba (peixe)		8 = Outro	
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WASH3Bj	Por que a sua família (não) trata essa água?																					
WASH3Bh	Quem é responsável por tratar a água?	0 = Não tratada Membro(s) da família: _____																				
WASH3Bi	No mês passado , quanto dinheiro foi gasto para tratar a água? R\$ _____																					

WASH3C. Agora, vamos falar sobre a outra fonte de água principal que vocês usam. Essa água também pode ser utilizada para beber, cozinhar e/ou outros gastos.	
Fonte:	Armazenamento inicial: Usos: Beber / Cozinhar / Outros gastos
WASH3Ck	Por que sua família usa esta fonte de água para (<i>usos</i>) e as outras fontes, não?
WS1-3C	Aproximadamente quanto dinheiro foi gasto pela água em casa no último mês ? R\$ _____ no mês ou ENERGIA (<i>paga apenas a energia que é incluído no gasto geral de energia para a casa</i>)
WASH3CI	A. Qual é a taxa de água? B. Tem que pagar se usar uma quantidade maior de água? Quanto paga? A. Taxa: R\$ ____ / ____ L / mês ou 2 meses ou Outro: ou 0 = Não tem NS = não sabe B. 0 = Não ou Sim: R\$ ____ / _____ L ou NA
WASH3Cn	O(a) senhor(a) acha que a sua água é cara? Por quê? 0 = Não 1 = Sim NA = Não aplicável NS = Não sabe Justificação:
WASH3Ca	Como a água é transportada do ponto de acesso à casa? <i>O ponto de acesso pode ser a cisterna, o açude, o poço, etc.</i> 1 = Encanada em casa 4 = Carro 7 = Motocicleta/moto 2 = Andando (a pé) 5 = Carrinho de mão 8 = Entregador 3 = Bicicleta 6 = Animal 9 = Outro _____
WASH3Cd	Quem é responsável por obter essa água para a casa? (Levar a água para casa, ligar para o entregador, ligar/desligar motor, pagar a taxa). <i>Anote a responsabilidade de cada pessoa.</i> Membro(s) da casa (gênero e idade): _____ Alguém fora de casa: Entregador / Família / Vizinho / Outro Responsabilidades:
WASH3Cb	Aproximadamente quanto tempo (em minutos) leva para ir à fonte de água, obter água e voltar (incluindo o tempo de espera)? _____ horas _____ minutos NS = Não sabe NA = Não aplicável
WASH3Cc	Quantos dias na semana a família pega água da fonte? Quantas viagens são feitas por dia? <i>Se a água é entregue:</i> Quantos dias na semana (ou mês) o entregador a entrega? Frequência de dias: Número de viagens por dia: Frequência: NS = Não sabe NA = Não aplicável
WASH3Ce	Este ano , em quais meses a sua família usou esta fonte? 1 2 3 4 5 6 7 8 9 10 11 12 13 = Todos os meses 0 = Nenhum mês
WASH3Cg	Tratamento Depois de receber essa água em casa, vocês fazem alguma coisa antes de usar ela, algum tipo de tratamento? Por exemplo, vocês coam a água ou botam cloro? <i>Se a água não é tratada, vá para WASH3B.</i> Quando vocês fazem esse tratamento? Com que frequência? 0 = Nunca 2 = Só quando a água esta suja 3 = Às vezes 4 = Sempre 5 = Não sabe 6 = Uma vez no ano 7 = Duas vezes no ano 8 = Outro (<i>descreva</i>) 9 = Apenas uma vez Processo 0 = Não 1 = Ferver a água 2 = Usar filtro (cerâmica, composto de areia, barro) 3 = Filtrar através de pano (tecido) ("coar") 4 = Colocar cloro/ água sanitária na água 5 = Uso de moringa/lírio branco 7 = Deixar a água parada 9 = Colocar piaba (peixe) 8 = Outro Frequência N/A
WASH3Cj	Por que a sua família (não) trata essa água?
WASH3Ch	Quem é responsável por tratar a água? 0 = Não tratada Membro(s) da família: _____
WASH3Ci	No mês passado , quanto dinheiro foi gasto para tratar a água? R\$ _____

7. Escala de acesso à água doméstica

Agora, vou lhe perguntar mais sobre suas experiências com acesso à água na casa. Para cada uma das perguntas, indique o quanto a situação aconteceu **nos últimos quatro meses (neste verão)**. *Escreva a frequência em detalhe quando possível (e.g., 3 dias/semana todos os meses, 1 vez por 10 dias, 1 dia) ou use a escala de frequência.*

Código	Pergunta e resposta
HWAS1a	Nos últimos quatro meses, a sua casa não teve água para beber em algum momento? Quantos dias isso aconteceu? _____
HWAS1b	Nos últimos quatro meses, houve dias em que a sua casa não teve água para outras atividades da casa, além de beber ? Quantos dias isso aconteceu? _____
HWAS2a	Nos últimos quatro meses, o abastecimento de água da fonte de água principal para beber foi interrompido alguma vez? Quantos dias isso aconteceu? _____ Fonte: _____ Armazenamento: _____ <i>Referencie/confirme a fonte (chuva, etc. e o armazenamento principal) segundo as respostas anteriores.</i>
HWAS2b	Nos últimos quatro meses, o abastecimento de água da fonte de água principal para outros gastos foi interrompido alguma vez? Quantos dias isso aconteceu? _____ Fonte: _____ Armazenamento: _____
HWAS3	Nos últimos quatro meses, houve dias em que a sua família não teve água suficiente para o quintal, as culturas (cultivo) ou as árvores ? Quantos dias isso aconteceu? _____
HWAS4	Nos últimos quatro meses, houve dias em que não teve água suficiente para os animais ? Quantos dias isso aconteceu? _____
HWAS5	Nos últimos quatro meses, o tempo gasto em pegar de água impediu o(a) senhor(a) ou alguém de sua casa de fazer outras atividades ? Quantos dias isso aconteceu? _____
HWAS6	Nos últimos quatro meses, o tempo gasto na obtenção de água impediu o(a) senhor(a) ou alguém de sua casa de ganhar dinheiro (e.g., engajar-se em trabalho remunerado, atividades econômicas)? Quantos dias isso aconteceu? _____
HWAS7b	Nos últimos quatro meses, houve momentos quando o(a) senhor(a) ou alguém da família não tinha condições para pagar pela sua água (incluindo combustível) ? Quantos dias isso aconteceu? _____
HWAS8	Nos últimos quatro meses, a família deixou de comprar outras coisas ou de realizar um pagamento para guardar dinheiro de pagar a água? Quantos dias isso aconteceu? _____
HWAS9	Nos últimos quatro meses, houve momentos quando o(a) senhor(a) ou alguém da família quis comprar água, mas não havia lugar para comprar ? Quantos dias isso aconteceu? _____ <i>Se a família não compra água, a frequência é "nunca" (0).</i>
HWAS10	<i>Se houver crianças na casa, pergunte. Se não, escreva NA e siga com HWAS11.</i> Nos últimos quatro meses, o tempo gasto para obter água impediu alguma vez o(a) senhor(a) ou alguém de sua família de cuidar das crianças em casa? Quantos dias isso aconteceu? _____
HWAS11	Nos últimos quatro meses, o tempo gasto na obtenção de água impediu o(a) senhor(a) ou alguém de sua casa de fazer tarefas domésticas (e.g., cozinhar, preparar alimentos, lavar roupa)? Quantos dias isso aconteceu? _____
HWAS12	<i>Se houver crianças na casa, pergunte. Se não, escreva NA e siga com HWAS13.</i> Nos últimos quatro meses, as crianças deixaram de ir à escola por falta de água? (e.g., por não poder tomar banho ou se alimentar; não tinha roupa limpa)? Quantos dias isso aconteceu? _____
HWAS13	Nos últimos quatro meses as limitações físicas impediram o(a) senhor(a) ou alguém da família de obter água? Quantos dias isso aconteceu? _____

FREQUÊNCIA: *Escreva o número de dias que aconteceu no campo em branco.*
Se for necessário, pode escrever as seguintes frequências: às vezes, muitas vezes, sempre
NA = Não aplicável, NS = Não sabe, NQ = Não quis responder

HWAS14	Nos últimos quatro meses, não houve água suficiente para lavar a roupa em algum momento? Quantos dias isso aconteceu? _____
HWAS15	Nos últimos quatro meses, o(a) senhor(a) ou alguém da sua família teve de mudar o consumo de alimentos porque não havia água suficiente (e.g., para lavar alimentos, cozinhar)? Quantos dias isso aconteceu? _____
HWAS16	Nos últimos quatro meses, o(a) senhor(a) ou alguém de sua família ficou sem poder lavar mãos depois de realizar atividades sujas (e.g., defecar ou trocar fraldas, limpar esterco de animais) por que não havia água suficiente? Quantos dias isso aconteceu? _____
HWAS17	<i>Se tiver crianças na casa, pergunte. Se não, escreva NA e siga com HWAS18.</i> Nos últimos quatro meses, o(a) senhor(a) ou alguém de sua casa não teve água suficiente para lavar os rostos e mãos das crianças em sua casa? Quantos dias isso aconteceu? _____
HWAS18	Nos últimos quatro meses, o(a) senhor(a) ou alguém de sua família teve que ficar sem poder tomar banho (ou lavar o corpo) por que não havia água suficiente? Quantos dias isso aconteceu? _____
HWAS19	Nos últimos quatro meses, o(a) senhor(a) ou alguém de sua família mudou a sua rotina porque teve que resolver um problema por conta da água? (Dar exemplos: e.g., falta, mau cheiro, problemas dos serviços) Quantos dias isso aconteceu? _____
HWAS20	Nos últimos quatro meses, os problemas com a água impediram o(a) senhor(a) ou outra pessoa na casa de participar de eventos sociais em sua comunidade (e.g., aniversários, igreja, funeral, reuniões comunitárias)? Quantos dias isso aconteceu? _____
HWAS21	Nos últimos 4 meses, vocês pediram água ou pegaram água de outras pessoas que não moravam na casa (incluindo família, vizinhos)? Quantos dias isso aconteceu? _____ <i>Nunca (0): continue com HWAS23.</i>
HWAS22a	De quem vocês pediram/pegaram água? 1. Família (vizinha) 2. Família (mesma comunidade, não vizinha) 3. Família (outra comunidade) 7. Outro 4. Não familiar (vizinhos) 5. Não familiar (mesma comunidade, não vizinha) 6. Não familiar (outra comunidade)
HWAS22b	Para que usos? 1 = Beber 3 = Cozinhar 5 = Lavar roupa 7 = Animais 9 = Outros usos 2 = Dentes 4 = Tomar banho 6 = Lavar louça 8 = Cultivos
HWAS22c	Que tipo de água foi? (e.g., de cisterna para beber, de cisterna de produção, água encanada...):
HWAS22d	A sua família recebeu a água suficiente? 0 = Não 1 = Sim
HWAS23a	Nos últimos quatro meses, vocês deram água para alguém que não morava em casa (incluindo família, vizinhos)? Isso inclui alguém pegando água da sua cisterna. Quantos dias isso aconteceu? _____ <i>Nunca (0): continue com HWAS24.</i>
HWAS23b	Para quem vocês deram essa água? 1. Família (vizinha) 2. Família (mesma comunidade, não vizinha) 3. Família (outra comunidade) 7. Outro 4. Não familiar (vizinhos) 5. Não familiar (mesma comunidade, não vizinha) 6. Não familiar (outra comunidade)
HWAS23c	Que tipo de água foi? (e.g., de cisterna para beber, de cisterna de produção, água encanada...):
HWAS24a	Nos últimos quatro meses, alguém (e.g., vizinhos, associações, a igreja, o operador do sistema) tem ajudado a sua família a garantir água? (Por exemplo, permitiu a família pegar água, compartilhou a cisterna, ajudou pagar a taxa da água encanada)? Quantos dias isso aconteceu? _____

FREQUÊNCIA: Escreva o número de dias que aconteceu no campo em branco.
Se for necessário, pode escrever as seguintes frequências: Às vezes, muitas vezes, sempre
NA = Não aplicável, NS = Não sabe, NQ = Não quis responder

HWAS24b	Este ano (2022) , a família participou num projeto relacionada à água? (Por exemplo, um programa de cisternas, perfuração de poço...) 0 = Não 1 = Sim NS = Não sabe
HWAS24c	<p><i>Se sim:</i> O(a) senhor(a) pode descrever o projeto? Qual tipo de projeto era e quando aconteceu?</p> <p>O tipo de projeto: 1 = cisterna domiciliar 2 = poço profundo (comunidade) 3 = poço profundo (particular) 4 = Caixa d'água comunitária 5 = Mudança para o SAAE 6 = outro</p> <p>Quando aconteceu (mês ou meses):</p> <p>Quem foi que organizou ou conseguiu o projeto? NS = Não sabe 1 = Alguém da sua casa 2 = Presidente/líder da comunidade 3 = Outro _____</p>
HWAS25	Nos últimos quatro meses, passou dias nos quais não houve água suficiente para o(a) senhor(a) ou para os membros de sua família? Quantos dias isso aconteceu? _____
HWAS26	Nos últimos quatro meses, houve dias nos quais não houve tanta água para beber como o(a) senhor(a) gostaria para o(a) senhor(a) mesmo ou alguém em sua casa? Quantos dias isso aconteceu? _____
HWAS27	Nos últimos quatro meses, o(a) senhor(a) ou alguém de sua casa não teve água suficiente para tomar medicamentos? Quantos dias isso aconteceu? _____
HWAS28	Nos últimos quatro meses, o(a) senhor(a) ou alguém de sua casa não conseguiu água onde queria porque estava muito doente ou fraco para conseguir água? Quantos dias aconteceu isso? _____
HWAS29	Nos últimos quatro meses, o(a) senhor(a) ou alguém da sua casa foi dormir com sede? Quantos dias isso aconteceu? _____
HWAS30	Nos últimos quatro meses, houve dias em que não teve água (nada) em sua casa? Quantos dias isso aconteceu? _____

8. Escala da qualidade da água do agregado familiar			
Agora vou perguntar sobre suas percepções da qualidade da água, tanto para beber como para os outros usos na casa.			
Código	Pergunta e respostas		
HWQS1	Nos últimos quatro meses, houve momentos em que a qualidade da água era inaceitável para o consumo humano? Ou seja, a família não bebeu essa água? Quantos dias isso aconteceu? _____		
HWQS1b	Fonte	Por que a água era inaceitável?	O que vocês fizeram?
HWQS2	Nos últimos quatro meses, houve momentos em que a qualidade da água era inaceitável para uso em tarefas domésticas e limpeza? Quantos dias isso aconteceu? _____		
HWQS2b	Fonte	Por que a água era inaceitável?	O que vocês fizeram?
HWQS3	Nos últimos quatro meses, houve momentos em que a qualidade da água era inaceitável para uso em animais? Quantos dias isso aconteceu? _____		
HWQS3b	Fonte	Por que a água era inaceitável?	O que vocês fizeram?

FREQUÊNCIA: Escreva o número de dias que aconteceu no campo em branco.
Se for necessário, pode escrever as seguintes frequências: As vezes, muitas vezes, sempre
NA = Não aplicável, NS = Não sabe, NQ = Não quis responder

HWQS4	Nos últimos quatro meses, o(a) senhor(a) observou sujeira ou outros pequenos flutuadores na água? Quantos dias isso aconteceu? Beber: _____ Outros usos: _____
HWQS5	Nos últimos quatro meses, o(a) senhor(a) sentiu mau cheiro ou forte cheiro vindo da água? Quantos dias isso aconteceu? Beber: _____ Outros usos: _____
HWQS6	Nos últimos quatro meses, o(a) senhor(a) ou alguém de sua casa bebeu água que tinha um gosto ruim ? Quantos dias isso aconteceu? _____
HWQS7	Nos últimos quatro meses, o(a) senhor(a) notou que a água era de uma cor diferente ou turva ? Quantos dias isso aconteceu? Beber: _____ Outros usos: _____
HWQS8	Nos últimos quatro meses, o(a) senhor(a) queria tratar a sua água, mas não podia ? Quantos dias isso aconteceu? Beber: _____ Outros usos: _____
HWQS9	Nos últimos quatro meses, o(a) senhor(a) ou alguém de sua casa bebeu água que o(a) senhor(a) achava ruim ? Quantos dias isso aconteceu? _____

FREQUÊNCIA: Escreva o número de dias que aconteceu no campo em branco.
 Se for necessário, pode escrever as seguintes frequências: Às vezes, muitas vezes, sempre
 NA = Não aplicável, NS = Não sabe, NQ = Não quis responder

9. Escala do estresse por causa da água do agregado familiar						
Agora vou perguntar-lhe sobre o seu sentimento relacionado com o uso da água, o acesso, a qualidade no agregado familiar. Para as primeiras perguntas, vamos usar uma escala de 1 a 5, onde 1 é sem sentir preocupado ou incomodado, e 5 é estar muito, muito preocupado.						
Escala: Preocupação HWAS1-4 A	1 Sem preocupação	2 Incomodado	3 Preocupado	4 Muito Preocupado	5 Muito muito preocupado	NA
FREQUÊNCIA: Escreva o número de dias que aconteceu no campo em branco. Se for necessário, pode escrever as seguintes frequências: Às vezes, muitas vezes, sempre NA = Não aplicável. NS = Não sabe, NQ = Não quis responder						
Código	Pergunta e resposta					
HWDS1	Nos últimos quatro meses, o(a) senhor(a) ou alguém de sua casa ficou incomodado(a) ou preocupado(a) de que não ter água suficiente para beber? A. Quão preocupado(a)? _____ B. Quantos dias sentiu assim? _____					
HWDS2	Nos últimos quatro meses, o(a) senhor(a) ou alguém de sua casa ficou incomodado(a) ou preocupado(a) de que não teria água suficiente para as outras necessidades domésticas? A. Quão preocupado(a)? _____ B. Quantos dias sentiu assim? _____					
HWDS3	Nos últimos quatro meses, o(a) senhor(a) ou alguém de sua casa ficou incomodado(a) ou preocupado(a) com sua segurança para ir buscar água para sua casa? (Por ex. durante o trajeto (a viagem, familiar), recolhendo a água ou voltando com a água) A. Quão preocupado(a)? _____ B. Quantos dias sentiu assim? _____					
HWDS4	Nos últimos quatro meses, o(a) senhor(a) ou alguém de sua casa ficou incomodado(a) ou preocupado(a) de beber ou usar a água pela qualidade dela? A. Quão preocupado(a)? _____ B. Quantos dias sentiu assim? _____					
HWDS5	Nos últimos quatro meses, o(a) senhor(a) ou alguém de sua casa teve problemas com vizinhos devido à problemas com a água? Quantos dias/vezes isso aconteceu? _____					
HWDS6	Nos últimos quatro meses, o(a) senhor(a) ou alguém de sua família teve problemas com água que causaram dificuldades dentro de sua casa? (e.g., brigas/discussões com familiares, mal-entendidos)? Quantos dias/vezes isso aconteceu? _____					
HWDS7	Nos últimos quatro meses, o(a) senhor(a) ou alguém de sua família se sentiu muito preocupada quando não tinha água suficiente para as necessidades na casa? Quantos dias sentiu assim? _____					
HWDS8	Nos últimas quatro meses, o(a) senhor(a) teve problemas com água que causaram dificuldades com o fornecedor (SAAE, a comunidade, o operador do sistema, etc.) ou vendedor de água? Quantos dias/vezes isso aconteceu? _____					
HWDS9	Nos últimos quatro meses, o(a) senhor(a) pensou alguma vez em deixar [nome da comunidade] por causa de problemas com água? Quantos dias/vezes pensou nisso? _____					

10. Insegurança alimentar (10 Itens)	
<i>Agora eu vou perguntar sobre suas experiências com acesso a comida nas últimas quatro semanas. Vou perguntar-lhe sobre as frequências que o(a) senhor(a) experimentou algumas situações, e eu gostaria que o(a) senhor(a) me dissesse com que frequência tem acontecido nas últimas quatro semanas.</i>	
Código	Pergunta e resposta
FI1	Nas últimas 4 semanas , o(a) senhor(a) teve preocupação que a comida na sua casa acabasse antes que o(a) senhor(a) tivesse acesso ou condições de comprar, receber ou produzir mais comida? Quantos dias? _____
FI2	Nas últimas 4 semanas , o(a) senhor(a) ou outra pessoa na sua casa deixou de comer comidas que gostaria por falta de produção, de condições de comprar comida ou de acesso? Quantos dias? _____
FI3	Nas últimas 4 semanas , o(a) senhor(a) ou outra na casa teve que limitar a variedade de comidas por falta de produção ou de condições de comprar comida ou de acesso? Quantos dias? _____
FI4	Nas últimas 4 semanas , o(a) senhor(a) ou algum membro da família teve que comer comidas que não queria por falta de produção, de condições de comprar comida ou de acesso? Quantos dias? _____
FI5	Nas últimas 4 semanas , teve que diminuir, alguma vez, a quantidade de alimentos nas refeições por que faltava comida em casa? Quantos dias? _____
FI6	Quantas refeições o(a) senhor(a) acha que deve comer em um dia? _____ refeições/dia
FI7	Nas últimas 4 semanas , o(a) senhor(a) ou algum membro da sua família comia menos refeições porque não havia comida suficiente alguma vez? Quantos dias? _____
FI8	Já passou um tempo sem nenhum tipo de comida em casa porque não havia produção ou condições de comprar comida? Nas últimas 4 semanas , quantos dias aconteceu? _____
FI9	Nas últimas 4 semanas , o(a) senhor(a) ou algum membro da sua família foi dormir à noite com fome porque não havia comida suficiente? Quantas vezes? _____
FI10	Nas últimas 4 semanas , o(a) senhor(a) ou algum membro da sua família se sentiu fome por um dia e uma noite inteiros devido à comida limitada na casa? Quantas vezes? _____

0 = Nunca (0 vezes)	1 = Raramente (1-2 vezes)	2 = Às vezes (3-10 vezes)	3 = Muitas vezes (11-20 vezes)	4 = Sempre (> 20 vezes)	NA = Não aplicável	NS = Não sabe	NQ = Não quis responder
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3. Questões de renda e habitação (13 Itens)	
<i>Agora, vamos rever algumas informações sobre a casa que não deveriam ter mudado desde a primeira vez que a gente conversou no inverno.</i>	
RH1	Qual é a ocupação do(a) senhor(a)? E dos outros (e.g., esposo, filhos) na casa? Quais são as fontes de renda da casa? (<i>Se for aposentado(a), indique isso e pergunte com o que trabalhou anteriormente.</i>)
RH2	A família recebe algum benefício de transferência da renda do Governo Federal? Qual? <i>Indique o número de benefícios ao lado do benefício.</i>
	0 = Não 1 = Sim: Auxílio Brasil / Bolsa Família _____ 2 = Sim: Aposentadoria _____ 3 = Sim: BPC _____ 4 = Sim: Outro _____
RH6	De quais atividades produtivas a sua família participa? (e.g., culturas, criar animais)?
	0 = Nenhuma 1 = Criação de animais _____ 2 = Feijão 3 = Milho 4 = Outras safras _____ 5 = Produção de leite 6 = Outro _____
RH16	A família usa irrigação? 0 = Não Sim: 1 = Inverno 2 = Verão 3 = Inverno e verão <i>Anotações:</i>
RH7	Quantos cômodos tem na casa? (<i>Não inclui os banheiros ou alpendre</i>) Quantos banheiros?
	Cômodos Banheiros
RH13	Qual é o material do revestimento?
	1 = Alvenaria (tijolos/blocos) 2 = Taipa 3 = Madeira 4 = Papelão 5 = Outros _____

RH14	Qual é o material do telhado?	1 = Telha de cerâmica 3 = Metal corrugado 5 = Palha 7 = Telha de barro	2 = Amianto 4 = Madeira 6 = Outro _____
RH9	Qual é a fonte de eletricidade?	Rede (rede pública de eletricidade) 1 = Monofásico / 4 = Trifásico / 5 = Não sabe 2 = Solar 0 = Nenhum 3 = Outros	
RH10	Que tipo de instalações sanitárias a sua família usa?	1 = Sistemas de canalização de esgotos 2 = Fossa séptica → ligada com esgoto 3 = Fossa séptica → não ligada com esgoto 4 = Balde 5 = Não sei / desconhecido 6 = Banheiros de compostagem 7 = Nenhum sistema; A céu aberto 8 = Outro _____ 9 = Buraco no chão	
RH11	As instalações de saneamento são compartilhadas com outras pessoas/famílias?	0 = Não compartilhadas 1 = Com uma família 2 = Com duas famílias 3 = Entre 3 e 6 famílias 4 = Acesso público 5 = Não aplicável: nenhum sistema	
RH12	Onde é que a sua família prepara a comida?	1 = Dentro da casa 2 = Fora / descoberto 3 = Fora / coberto	
RH15	Qual é a condição da propriedade da casa?	1 = própria (quitada) 2 = própria (hipoteca/financiamento) 3 = aluguel 4 = Posse ilegal 5 = Compartilhado / família 6 = Cedida/emprestada 7 = Outro _____	
RH0	Onde o(a) senhor(a) estudou? <i>Anote o nível de estudos.</i>	0 = Analfabeto 1 = Sabe ler e escrever 2 = Ensino Fundamental - até a 4ª série 3 = Ensino Fundamental - de 5ª a 8ª série 4 = Ensino Médio – Incompleto 5 = Ensino Médio – Completo 6 = Ensino Superior – Incompleto 7 = Ensino Superior – Completo 8 = Mestrado ou doutorado 9 = outro	

Pergunta final. Muito obrigada pela sua participação na pesquisa. **O(a) senhor(a) tem mais alguma coisa que gostaria de comentar ou perguntar?**

Votação. Onde o(a) senhor(a) votou nas eleições deste ano (2022)? Votou em qual bairro? Votou em qual local/endereço?

1 = Local de votação neste município [use lista de locais de votação]: _____
2 = Em outro município do Ceará
3 = Não votou 4 = Não sabe 5 = Não quer responder 6 = Outro: _____

Contacto. O(a) senhor(a) poderia nós dar um número de contato por se precisarmos verificar alguma informação?

Nome:

Número (com DDD):

Qualidade dos dados: Para que o entrevistador completar <i>Dê sua avaliação sobre a qualidade e confiabilidade dos dados coletados nesta pesquisa.</i>		
DQ01	O entrevistado mostrou algum dos seguintes? (Marque todas as que se aplicam)	0 = Nenhum 1 = Desconfiança de você ou do estudo 2 = Desonestidade, mentir ou inventar respostas que não pareciam verdadeiras 3 = Medo de você ou do estudo 4 = Hostilidade, raiva ou ressentimento 5 = Evasão ou tentando evitar responder
DQ02	Houve interrupções ou distrações?	0 = Não 1 = Sim, mas eu não acho que tenha influenciado as respostas 2 = Sim, e acho que isso influenciou as respostas
DQ03	Qual é a sua avaliação geral da qualidade dos dados nesta pesquisa?	0 = Excelente: O entrevistado entendeu o inquérito e esteve envolvido e não houve interrupções 1 = Tudo bem: O participante pode não ter entendido todo ou parte do inquérito bem ou houve algumas interrupções. 2 = Suspeito: O participante entendeu mal a pesquisa ou participou bem ou houve muitas interrupções.
DQ04	A qualidade dos dados desta entrevista é realmente importante para nós. Explique suas respostas acima, em termos de como os dados podem ter sido afetados. Há mais alguma coisa que precisamos saber?	