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Knowing Groundwater: Embodied Encounters with a Lively Resource

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ABSTRACT: This paper is concerned with how water prospectors, well diggers, and irrigation farmers come to know groundwater. Drawing on cases from Tanzania and Zimbabwe, the paper shows that much knowledge is derived from the close encounters with groundwater that occur through hard physical work, mediated by the use of low-cost tools and technologies. In this paper we show how this knowledge is embedded in everyday livelihoods, landscapes, and moral ecological rationalities. Through empirical material of such close encounters with groundwater, we make two interrelated points. Firstly, we draw attention to the importance of embodied forms of knowledge in shaping engagements with groundwater. Frequent close physical interactions with groundwater generate rich and intimate understandings of the changing quality and quantity of water flows. These understandings become primary ways in which people in communities know water, which is lively and sometimes invisible. Secondly, we argue that, though apparently mundane, reliant on low-cost technology, and highly localised, these encounters significantly shape broader socio-natural relationships in emerging groundwater economies. Amongst other examples, our data show groundwater prospectors monitoring the depth of borehole drilling in a shared aquifer in an attempt to ensure equitable access for different users. In concluding the paper, we reflect on the extent to which the knowledge and relationships formed through close physical encounters with groundwater have the potential to shape trajectories of groundwater management.

KEYWORDS: Embodied knowledge, farmers, groundwater economies, prospectors, well diggers, Tanzania, Zimbabwe

INTRODUCTION

In recent years there has been an upsurge of interest in the potential for groundwater in the development of irrigated agriculture in sub-Saharan Africa. Indeed, it is argued that a groundwater boom could have a number of benefits in terms of increased water and food security, poverty alleviation, and drought relief (Cobbing and Hiller, 2019). Parallel to arguments about groundwater exploitation are those that point to the key role of farmers in irrigation development and the place of smallholder agricultural water use in invigorating local and regional economies (Veldwisch et al., 2019). In the vibrant body of research that details groundwater-agriculture dynamics in sub-Saharan Africa, there is recognition that these are shaped by local conditions, low-cost technologies, highly labour-intensive processes, and social differentiation (Lefore et al., 2019). Social dimensions are key to the development and management of groundwater for agriculture, and research on these touches on issues of power, access, community regulation, stakeholder engagement, and the links to land ownership and use (Mitchell et al., 2012). However, one area which has received little critical scrutiny to date is the hard physical work required to secure access to water in emerging groundwater economies, and the knowledge of – and intimate relationship with – the water that is generated through it. Our paper is a modest attempt to address this gap.

Groundwater is a notoriously elusive resource. Due to its underground location, it can be challenging to identify and to comprehend its quality, volume, and direction of flow. While plants intelligibly seek out the presence of groundwater – sensing its chemistry, location, and flows with their roots – such a direct encounter with an aquifer and its waters is tricky for human actors. Therefore, humans deploy both imagination and instruments to make sense of an aquifer, the water it holds, and where it flows (cf. Ballestero, 2019). Such methods often offer only limited comprehension of groundwater: the politics and social relations of measuring, accessing, sharing, and using groundwater typically build on conceptual images and articulations that never fully capture the lively qualities of underground water flows (Zwarteveen et al., 2017). In addition to formal measurement technologies, ecological understandings that are locally situated, subjective, embodied, and socially sanctioned (e.g. moral, cultural, or religious) play an important role in the understandings of aquifers and groundwater flows (Komakech and de Bont, 2018; Zwarteveen et al., 2021; Chitata et al., 2022).

There are certain people who undertake work in close physical proximity with aquifers and groundwater, deploying and generating knowledge and conceptualisations as they do so. For example, well diggers who hand-dig their way into aquifers encounter the textures of soil and rock and the flows of water with their bodies; farmers who clean the inside of a tank which stores groundwater pumped up from an aquifer feel and smell this water directly. In the context of fast-growing local groundwater economies, the embodied and applied knowledge of these people shapes how groundwater is understood and accessed in communities, and how it may be shared and cared for.

The starting point for this paper is the assertion that all knowledge of groundwater is, to varying degrees, shaped in embodied practice, mediated by technology and imagination, and formed in particular socio-ecological contexts. The cases researched in our wider Transformations to Groundwater Sustainability (T2GS) project[1] abound with examples of farmers learning to manage the recharge of groundwater in wells, or the distributions of water flowing through pumps, pipes, and canals to their fields (Zwarteveen et al., 2021). We recognise that the technicians of drilling companies, the planners and engineers of irrigation schemes may encounter this resource through sophisticated equipment and technologies, and that the use of these is also embodied and located in professional and social milieux (Patra et al., 2016). But our focus here is on the repeated, embodied, and practical experiences of men[2]

[1] https://www.t2sgroundwater.org/

[2] While in many cases women are the ones encountering and working with groundwater for agricultural and domestic purposes, our cases focus on the work of men. This is because the type of tasks that we investigate – water prospecting, irrigation system

(prospectors, well diggers, and farmers) who do direct physical work in close proximity with groundwater and related infrastructure. Through these everyday bodily encounters, they become skilled in knowing the lively properties of the aquifer and the water it contains. In this paper we draw on vignettes of such encounters in Zimbabwe and Tanzania to explore how the situated and embodied knowledge of prospectors, well diggers, and farmers is deployed to access and manage groundwater flows.[3]

We argue that tracking these close physical encounters matters because they yield intimate knowledge of the aquifer and of groundwater. This knowledge may complement or deviate from the knowledge of formally trained hydrologists, contractors, and technicians and offer different insights into people-water relationships. Documenting experiences of embodied encounters with groundwater and the understandings that they generate is important to our project of pluralising groundwater knowledges (Zwarteveen et al., 2021). These encounters are also significant because they have the potential to shape distribution of water in more or less equitable ways. Other research suggests the significant role that farmers themselves play in driving irrigation expansion at the local level in sub-Saharan Africa (Woodhouse et al., 2017). But farmers are only part of the cast of those actors shaping access to water through physical labour; in our study, prospectors and well diggers also have a part to play. We argue that examining the embodied groundwater encounters of farmers, prospectors, and well diggers offers insights into development and sustainability dilemmas in places where irrigated agriculture is expanding without widespread access to sophisticated technologies and formal geo-hydrological knowledge.

GROUNDWATER – ENCOUNTERING A LIVELY RESOURCE

The encounters that we consider here occur in relation to groundwater and the aquifer which contains it. The aquifer is the geology – the layers of rock and sediment which are to greater or lesser extent porous. It is through the fissures and spaces in these geological layers that the groundwater seeps. There is considerable variety in the composition of aquifers; they may be made of different types of rock or sediment, be deep or shallow, be confined under an impenetrable layer of rock or more easily accessible just below a permeable layer of soil, and they may be connected to other flows and bodies of water in complex ways. The scale of aquifers varies: alluvial aquifers may be vast in scale and used by thousands of farmers, whilst smaller, localised, hard rock aquifers are more regularly used for domestic water as well as for farming (Srinivasan and Kulkarni, 2014; Kulkarni et al., 2015). The water contained in aquifers is recharged from rainfall, but not necessarily in the immediate location of the well or borehole, connecting different spatial locations. Some water may have been contained in the aquifer for thousands of years, while in other cases the aquifers are seasonally recharged. A key global concern, given the number of people who depend on groundwater, is that its extraction for expanding and intensifying agricultural production may exceed the capacity of aquifers to replenish themselves (Molle et al., 2018; van der Gun, 2019).

Accessing groundwater necessarily means making connections between the water, rocks, soils, people, and technologies. The nature of the aquifer imposes certain requirements on those hoping to extract water from it. Some form of technology is often required to dig or drill through the layers of rock and sediment to reach the water and to lift the water from the well or borehole. Varying degrees of physical labour are required, according to the type of technologies employed. Because the water is underground, localised knowledge of landscape features, rocks, and soils, and knowledge of how water

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cleaning, and well-digging – are seen primarily as men's work in the study communities. Women's encounters with groundwater are explored in Leonardelli et al. in this issue.

[3] We use the term 'vignettes' to convey the idea that these are brief evocative descriptions of the processes which concern us in this paper (accessing and managing groundwater through physical labour). The descriptions emerge from our wider research on groundwater governance, which was not designed to address these issues specifically. Therefore, the Zimbabwe and Tanzania vignettes are not directly comparable, and focus on different elements of embodied knowledge. We argue that, nonetheless, they clearly indicate some key issues worthy of exploration.

behaves – seeping, flowing, and bursting out – is essential to access it. Additionally, if the aim is to sustain the supply of water, users need to have some knowledge of how the aquifer recharges and how use of one well or borehole may affect the water level in others.

As most people never physically encounter an aquifer, which may be hidden or partially invisible, imagination is required to comprehend it. Different imaginings of the aquifer exist in scientific and lay knowledge. Analogies vary in the extent to which the aquifer and groundwater are represented as dynamic or static in nature. Perhaps closest to a geological explanation is the comparison of an aquifer to a pile of wet laundry sandwiched between layers of rock (Jiang et al., 2021), or a rock sponge, whilst in public imagination aquifers commonly manifest as vast underground lakes or flowing rivers. In some local understandings, the aquifer is considered analogous to the circulatory system of the human body with its system of veins, arteries, and capillaries (Bekkar et al., 2009). In working through the examples of close physical encounters in this paper, it is clear that the farmers, prospectors, and well diggers do not see aquifers and groundwater only as inanimate 'things', but also as vibrant matter with its own distinctive characteristics (cf. Bennett, 2010; Beetz, 2017; Anderson, 2020). In the cases that we explore here, the lively properties of water are very apparent: water is to varying degrees fugitive, unpredictable, forceful, and capable of carrying and dissolving other matters. We will show how the prospectors work to divine water by its energy, a process they describe as connecting the electricity of their body to that of the water. The well diggers have to account for the unpredictable ways in which water may burst out when a rock layer is pierced, and the farmers understand the groundwater stored in tanks as the medium that supports algae, which channels communication with ancestral spirits (Chitata et al., 2022). Practical knowledge of the liveliness of water, and how to relate to it, is built up from repeated interactions over time in specific environmental and social locations.

Our approach in this paper is consistent with recent approaches in social sciences and humanities, which "engage with the liveliness of the world, and see it not as an inanimate backdrop to human drama but as an animate participant in it" (Singh, 2018: 3). The liveliness of aquifers and groundwater engages and connects human actors in various ways, and we explore encounters inside the aquifer and on the ground to better understand these connections.

SITUATED AND EMBODIED KNOWLEDGE

Turning to the human actors in the unfolding relations of groundwater use, we understand the encounters between people, aquifers, and groundwater as imaginative and embodied, situated in particular socio-ecological *milieux*. In academic literature on human-environment relations, considerable attention has been paid to the ways in which people's knowledge of the environment cannot be separated from the experience of living in it (Ignatow, 2007; Longhurst, 2009; Ingold, 2021; Schnegg, 2021). Knowledge is formed through the ways in which social actors inhabit physical bodies (with particular characteristics and capabilities) and experience the environment through a consciousness generated via physical movement, the senses, and emotions – in other words, through lived experience (Ó'sabhain and McGrath, 2019). Drawing on such scholarship, we adopt a 'more-than-representational' approach to knowledge.

In this view of knowledge, a focus on practice becomes important: it is through the repeated practices of everyday life that people become enskilled in certain tasks and gain an understanding of the world (Ingold, 2002). The landscapes in which the bodily encounters take place are social and moral as well as physical. The hard labour of the individual water prospector, well digger, or irrigator is also embedded in connections with other people and with the environment. We find it helpful to see these relationships as moral-ecological, concerning vernacular patterns of beliefs and practices that shape people's reciprocal and affective relations with nature and place (Griffen and Robertson, 2016; Jacoby, 2014). Moral ecologies encompass ideas about rightful shares, fair distributions, and pathways of cause and effect in the human and more-than-human world (Cleaver, 2000; Cleaver et al., 2021; Scaramelli, 2021). It is often through moral ecological framings that claims to livelihoods are made, the authority of particular forms of knowledge is upheld, and governance arrangements are legitimised or disputed (Cleaver, 2012, 2018). 'Knowing' therefore involves skilled encounters between people, things, and natural and supernatural phenomena; conceptual and practical knowledge are interlinked.

Key to our conceptualisation of knowledge-as-embodied practice is that this is situated knowledge, made by people located in particular cultural, spatial, and temporal contexts (Longhurst, 2009). For our purposes, these contexts consist of the intersecting biophysical and material properties of the environment; the socio-cultural configuration of the communities in which these groundwaters exist (including the rules, norms and moral-ecological framings of resource use); and the wider political economy of society and the discourses which sustain it (cf. Whaley, 2018). In translating these elements to be of specific relevance to our study, we are also mindful of the nature of the aquifer and the terrain in which water is encountered; the distributions of wealth and labour in the communities which enable some people to access water through private wells while others are dependent on collective arrangements; the vernacular explanations which connect the behaviour of people to animals, plants, and spirits; and the drivers of groundwater exploitation, among others.[4]

In critical water studies, a range of literature, often informed by feminist approaches, touches on the ways in which engagements with water are enacted through human bodies. This includes literature on the gendered dimensions of agricultural and domestic water work (Jackson and Palmer-Jones, 1999); the perceptions and bodily risks of 'good' and 'bad' water (Sultana, 2013; Senanayake, 2020); the ways that gendered bodies are deployed to claim rights or resist unfair allocations (Vera Delgado and Zwarteveen, 2008); the sensory experience of water in everyday tasks (Pink, 2005); bodily exclusions from water on the basis of caste, race, or gender (Joshi and Fawcett, 2020); and the socio-spatial exercise of voice in watery landscapes (Impey, 2007). Implicit in many of these studies is the idea that human agency can be better understood by looking more closely at practices and experiences of the body in relation to the material and natural as well as the social world. For example, one study of a canal operator on an irrigation scheme in Mexico neatly illustrates how his ability to regulate water flows and distributions depends on enacting embodied knowledge, built up in place through repeated interactions with people, water, and technologies (Rap and van der Zaag, 2019). Drawing on this literature, our understanding of embodied agency encompasses everyday practices which are meaningful and situated. These practices generate knowledge of water and soils through physical labour, and understandings of the socio-natural world mediated through moral ecological rationalities and low-cost technologies.

Regarding the last point about socio-technical dimensions: tools, technologies, and infrastructure shape water flows, make connections, and are crucially entangled with embodied groundwater encounters. They shape how we think about the world (Rogoff, 2008) and necessitate and enable bodily encounters with water. In our exploration of embodied encounters, we consider how tools function as an extension of the body, facilitating and channelling the generation of embodied knowledge of groundwater and the aquifer.

THE T2GS PROJECT: BACKGROUND AND METHODS

In this paper, we bring empirical material from our research in Zimbabwe and Tanzania into a conversation. We explore three scenarios of apparently mundane activities: the siting of a borehole, the digging of a well, and the cleaning of a groundwater storage tank. These localised, low cost, intensely physical encounters may seem small scale and relatively unimportant in the global context of managing water, but we argue that they yield rich insights into the multiple dimensions of embodied encounters

[4] We do not have space in this paper to describe these different elements in detail, though the interested reader can explore further in related papers, cited here. In this paper we focus specifically on demonstrating the importance of embodied practices, picking out in our discussion some of the likely intersections with the physical and socio-cultural context.

with aquifers and with groundwater. They are an important subject of study, as it is through such encounters that many people across the globe shape their relationships with groundwater and contend with its inherent development and sustainability challenges.

Our approach in bringing these dissimilar cases into engagement is informed by the focus of the T2GS project: the comparative study of promising grassroots initiatives of people organising around groundwater in places where there is acute pressure on the resource, or where groundwater use offers new potentials for local economic development. In the project, we have used a variety of methods to study practices of knowing, accessing, and sharing groundwater (Zwarteveen et al., 2021). The material we include here is derived from our T2GS work in Tanzania and Zimbabwe.

In Zimbabwe, our study takes place in the context of increasing groundwater use in the smallholder irrigation sector and expanding state and farmer-led irrigation (Scoones et al., 2019). Nationally, the area under smallholder irrigation increased from 11,000 ha in 1999 to 220,000 ha in 2018 (Mosello et al., 2017; Muhoyi and Mbonigaba, 2021). Thus, smallholder irrigation has increasingly become a critical component of the food security arrangements in rural areas, where rainfed agriculture fails in three out of five years due to drought (Mugabe, 2005; Chitata et al., 2014). Groundwater is preferred for various reasons: it may be the only reliable source of water available (Chitata et al., 2021); it is relatively easy to access; it is often beyond the monitoring and regulatory capacity of the Zimbabwe National Water Authority (Banhire et al., 2019). Moreover, farmers use their embodied knowledge to evade the cost of expensive modern groundwater prospecting methods. This partly explains how Zimbabwean farmers can afford to rely on groundwater for their water security (Dzwairo et al., 2006).

The setting of the Zimbabwean vignettes is in and around the Rufaro irrigation scheme in Masvingo province. Relations with groundwater in the Rufaro area are intertwined with the socio-cultural lives of the Karanga people, who were resettled in the area after independence in 1980. To these people, water is culturally linked to the environment, to ancestral spirits, and to multiple values. Knowledge about the groundwater is passed on from generation to generation (see Chitata et al., 2022 for the culture of the Karanga people).

Through the Zimbabwe vignettes, we explore how particular forms of knowledge and types of infrastructure shape the relationships between people, the irrigation system, and the environment (Chitata et al., 2021). Embodied knowledge of the properties of groundwater interacts with cultural understandings of the role of spirits in resource governance and maintaining socio-political orders, and with logics of care and control. We conceptualise this knowledge as a form of hybridised moral ecological rationality (Chitata et al., 2022). Of note is how, in the contemporary moral ecologies that shape the practices of the Rufaro community, hierarchies in the spiritual realm are mirrored and connected to social power relations.

The Zimbabwe vignettes are derived from data collected by Tavengwa Chitata using ethnographic immersion over two years. During this time, several rounds of in-depth semi-structured interviews were conducted with groundwater prospectors, irrigators, private borehole owners, and members of Zimbabwe National Water Authority. Participant observations were used particularly during the prospecting process and the operation and maintenance of groundwater/irrigation infrastructures.

In the Tanzanian context, groundwater use is also increasing. Whereas a 2010 review of groundwater use in Tanzania hardly mentions the use of groundwater for irrigation outside of a few large plantations (Kashaigili, 2010), there is now growing evidence that smallholders are using it to cultivate both cash and staple crops (Shemsanga et al., 2018; de Bont et al., 2019a). They do this in spite of an irrigation policy (Lankford, 2004) that hardly mentions groundwater and a policy discourse that links groundwater solely to large-scale investors. Farmers intentionally but also opportunistically invest in groundwater wells to expand and intensify agriculture. The scale of this development is as yet unknown, as most of these farmers operate outside the view of government agencies and make use of the informal sector to site, design, develop, and use shallow wells (Komakech and de Bont, 2018). These developments are creating local groundwater economies that result in higher cropping intensities, better harvests, and improved household income, whether through irrigated agriculture or the economic activities and land markets associated with it. The emerging groundwater economy is the result of increasing river water shortages as well as growing markets for vegetables and staple crops in urban areas. Groundwater exploitation, however, requires access to technology, knowledge, and financial capital (de Bont et al., 2019a).

The Tanzanian vignette focuses on how farmers and well diggers relate to groundwater in areas where groundwater use for agriculture has dramatically increased during the last decade (de Bont et al., 2019a, 2019b; Komakech and de Bont, 2018). Located in Meru District, Arusha region, the research includes an in-depth study of well diggers' role in facilitating the recent turn to irrigated agriculture, exploring their knowledges and practices as well as their challenges. Limited hydrogeological studies have been conducted in this area (for an exception see Bennet et al., 2022), but the physical configuration of the aquifer is such that farmers are able to access water through hand-dug wells. The area is often characterised in literature as having a long history of in-migration, agricultural intensification, and market expansion. Despite the increasing use of water as an economic good for irrigation, it seems that cultural principles of non-exclusion in the Meru area remain strong (Ueda, 2000; Hillbom, 2012). There is a longstanding literature concerning various moral-ecological framings of people-nature relationships in Tanzania (Maddox et al., 1996) and rich studies of the way that these are hybrid, dynamic, and very much a part of contemporary life (Vähäkangas, 2015). They did not, however, seem to be salient in the accounts given by well diggers of their work. Possible explanations for this could include the significant levels of migration into the area, recent groundwater development (in the last two decades), and the dominance of ideas about modernity, though such conditions do not necessarily preclude the existence of hybridised moral ecological beliefs.

The embodied knowledge and physical labour required to access groundwater in Meru was captured through a photo elicitation process in which a well digger himself took photos of the process of accessing an aquifer and groundwater and then gave a narrative account of each photo. It is the narrative of the well digger that we draw on for the vignette presented here. Data collection for the Tanzania case was primarily undertaken by field researcher Kerstin Joseph and was designed and coordinated by Chris De Bont.[5]

PROSPECTING FOR WATER – ZIMBABWE

In the Rufaro area, situated in the Masvingo province of Zimbabwe, groundwater is used for both irrigation and domestic purposes. For decades, the community has relied on eight boreholes in the Rufaro Irrigation Scheme for irrigated farming and one hand pump for domestic water uses. However, in the recent past, the drilling and use of private boreholes for agricultural and domestic needs have been on the increase as individuals with the capacity to finance themselves increasingly want to expand private irrigation and production of cash crops. Most of the people who are drilling these private boreholes are relatively young and not members of the Rufaro Irrigation Scheme. It is the siting of these private and communal boreholes that is the focus of this vignette.

Any development and investment which requires water depends on the people who do the groundwater prospecting and the drilling. Prospecting using modern means or machines is expensive and beyond the reach of many rural farmers in the Rufaro area. To reduce the costs, farmers seek the services

[5] In both Zimbabwe and Tanzania, the research was undertaken in local languages (Shona and Swahili) as well as in English and was translated into English by the researchers.

of locals who can prospect and identify locations of high water yield. These people have built their knowledge of the groundwater flows and where to find them using their experiences of the area, their reading of the vegetation, and through the use of different tools as well as their own bodies. For example, for prospectors and farmers in Rufaro, groundwater is understood as an underground river system with pools which are connected to surface waters. The Rufaro community draws its water from an unconfined alluvial aquifer which is bounded by impermeable mountain escarpment in the eastern and northern parts and interacts with a large water body (Lake Mutirikwi) 20-30 km to the south. The aquifer system in the Rufaro area is believed to be on a lower elevation than Lake Mutirikwi, and in extreme droughts water from Lake Mutirikwi replenishes the Rufaro aquifer. In this Rufaro area, prospectors have developed an understanding of the landscape in relation to the groundwater. For example, some tree species are believed to grow along the underground rivers, and the greening of a particular grass species in the dry summer is seen as indicative of an underground pool. These and other understandings of groundwater and the aquifer underpin the bodily experiences of accessing and caring for groundwater flows with low-cost tools.

To date there are ten private boreholes[6] in the area which have been sited using the local groundwater prospectors[7] and which are used for domestic and private irrigation purposes. Among the three groundwater prospectors in the area, two started detecting groundwater in the late ’70s, having been mentored and initiated into the practice by their (grand)parents. These two prospectors are preferred in the Rufaro community because they do not charge their fellow community members; the community members generally feel indebted to give them a token of appreciation in the form of money or reciprocal goodwill.[8] These prospectors charge a fee of US$200-300 when they are contracted to prospect for groundwater outside the community or when working for commercial drilling companies.

The prospectors use a freshly cut Y-stick or copper wires (as divining tools) and their knowledge of where trees grow above-ground and where water flows underground to identify where to drill for water. To the community members, the practice of groundwater prospecting appears to be a simple practice carried out with mundane tools. But the work of groundwater prospecting using a Y-stick takes a physical and emotional toll on the prospectors. They pay dearly with their hands, heart, and emotions to locate water so that the community members know where to drill their boreholes. As one of the groundwater prospectors explained, his bodily faculties and anatomy are all brought to the search for water:

> For me, groundwater prospecting and success is linked to my heart’s ability to generate electricity, which depends on the pumping rate of your heart. During the practice I have to be able to instruct my brain to generate adrenaline, which creates a situation where the heart will pump faster.[9]

For this prospector, to get the brain to start releasing enough adrenaline to connect with the underground water requires extreme concentration and emotional disengagement with the physical environment, which he found difficult to explain. The other prospector revealed that his adrenaline is triggered by the fear of failure and his responsibility to care for the groundwater on behalf of the people and of the ancestors who initiated him as a groundwater prospector (a family trade). According to the prospectors, it is the electricity generated by the blood rush that is transmitted through the wires or Y-

[6] These boreholes are mostly financed through remittances and sale of domestic animals like cattle and sheep.

[7] We deliberately choose to use the term 'prospectors', rather than the more commonly used 'diviners'. We do this to emphasise the part that these actors play in the contemporary groundwater economy. To us the term 'prospectors' neatly captures a flavour of the frontier dynamics of searching for water underground and infers that this is more than a cultural practice, steeped in tradition and in communion with the sacred.

[8] The farmers may in the future help the groundwater prospector with water if the public borehole is not functioning or help him in any way when he is in need. This indirect form of non-specific generalised reciprocity is very common in Zimbabwean communities.

[9] Interview with prospector of groundwater number 1 (P1).

sticks to communicate with the water underground: "The electricity I generate is transmitted through the Y-wooden stick or the copper wires I use to assist me with signalling where to get a high yield of water".[10]

The sticks are held firmly in the hands, and with each hand on one side of the Y-stick, the prospectors move up and down. When they get to a position where there is a high yield of groundwater, the Y-stick will move up or down and to indicate the position of high water yield:

> You should hold the stick firmly against its pull at the same time maintaining a high adrenaline or high heart pumping rate until you cannot withstand this pull. The pull is very strong, and you should hold the stick against this pull, which is painful, and it is the reason why my hands are chapped and blistered.[11]

Figure 1. Groundwater prospector showing his blistered hand, apparently the result of his prospecting practice.

Source: Photo courtesy of Tavengwa Chitata 2021.

The other prospector also highlights how his own body is physically engaged and at the same time put at risk by the movement of the Y-stick in the process of prospecting: "Sometimes you can get hit either in the face or between the legs, and you will have to sit and recover".[12] The aftermath of prospecting is also considered tough, as one of the prospectors indicated:

> Prospecting for groundwater is emotionally and physically draining. The communication between the heart and water weakens the body, and it usually takes me three days to fully recover. I can liken the tiredness to how a runner feels soon after finishing a 100 m race at national competitions.[13]

To these prospectors, groundwater prospecting is not only a way of making a living – usually realized when practicing outside their community or contracted by the drilling companies as a paid job – but is also a higher-level duty of care for groundwater and of ensuring the equitable sharing of water amongst the people of Rufaro. Despite the physical toil they experience, the prospectors insist they will continue

[10] P1

[11] P1

[12] P2

[13] P1

to offer this service to the members of their community for free because they care for their groundwater. They feel it is their responsibility to take care of their groundwater; otherwise, an external person will come to prospect using machinery. Those people will then be able to drill deeper than the existing boreholes, which will create a flow gradient towards the new, deeper borehole, with negative implications for water access by the other private borehole owners. As the prospectors highlighted: "We were mentored to be sensitive to water, so it's part of us, and it will be neglect of duty to let water be a cause of conflict or to allow certain individuals to disadvantage others in accessing water".[14]

The prospectors also monitor the drilling of boreholes by the commercial companies to ensure that they drill to their recommended depth.[15] They try to ensure that all the boreholes sharing the same aquifer are taking water from the same depth, in order to maintain equal access and avoid drying other private boreholes by creating excessive flow gradients. This they do by factoring the position of boreholes on the slope. The prospectors go so far as not to disclose the depth of different boreholes as a way of thwarting borehole depth competition. As one of the prospectors explained:

> We do not allow drillers to drill to more than necessary depth; the standard practice here is they drill 10 m further down after reaching the last rock fracture. This ensures equitable access to groundwater to those who have the boreholes and those who will have theirs in the future. We do not tell this information to private borehole owners, lest it will be used for ill intent – to disadvantage others – as some will think of deepening their boreholes unnecessarily. If they drill deeper, it's like building ten houses when you can only stay in one house; that is, wasting a resource and creating artificial shortage.[16]

The prospectors are in this way shaping the local groundwater economy, both by facilitating the sinking of individual boreholes and by working to control the depth at which boreholes are sunk across the area. The care that prospectors take for the equitable sharing of groundwater is based on their understanding of their moral-ecological responsibilities, and the intimate relation with groundwater that they have acquired through hard physical prospecting work.

For the next vignette, we turn to Tanzania and detail the experience of those using their bodies and tools to dig wells for farmers.

DIGGING INSIDE THE AQUIFER – TANZANIA

Our research location in Tanzania lies on the plain stretching out south from Mount Meru, into Meru District, Arusha region. The main economic activities for people here include livestock keeping, agriculture, and petty business, but there are also people who engage in artisanal tanzanite mining activities at nearby Mererani. With the increased interest in irrigation wells, men skilled in digging have found a new source of income in well-digging. Although professional borehole drillers are active in the country, their costs are beyond the reach of most smallholder farmers. To be able to access the underground aquifer, smallholder farmers rely on well diggers using local technology and knowledge to prospect and dig wells. Skilled diggers with experience from mining but also from digging pit latrines and graves are available to meet the demand of farmers for accessing groundwater.

We take the final phase of digging an irrigation well as an example of learning about groundwater through the experiences of the well diggers' work inside an aquifer. When the well digger has dug through the initial layers of soil and loose rock to reach the aquifer, he (there are no women known to be commercial well diggers in this area) has to continue to dig inside the aquifer in order to deepen it or 'open it up' so that enough water can flow into the well. The well diggers conceptualize this in Swahili as *kuzibua mikondo ya maji*, literally, 'to unblock the water channels', or just *kuzibua*. For an irrigation well,

[14] P3

[15] The recommended depth is no deeper than the first borehole drilled in the area.

[16] P1

the work of digging sufficiently deep is more demanding and riskier than deepening a well for domestic water use, simply because an irrigation well must produce a greater quantity of water to be economically viable. Or, as the well diggers put it, you need to dig until water comes up to the level of the shoulders for an irrigation well, while it is enough to dig until water comes up to the brim of a bucket for a domestic well. Hence, when digging an irrigation well, the digger literally has to dig the last stretch of the well *inside the aquifer*. As will be described below, this requires specific skills and preparedness for how to manage the encounter with the aquifer and its water to reduce the evident risks of bodily harm. When digging a domestic well, the risks related to kuzibua work are not present in the same way.

This is the process of deepening a well through kuzibua, in the words of the well diggers:

> When digging a well (…) there is a stage you reach [where] you find water, but the water at this stage is not a lot. When you encounter this first phase of water, you keep on digging until you have reached a cement-like layer. At that stage, you continue digging until you break the layer. When you break this layer, water comes out very forcefully. [17]

> You first set the machine to pump out water until it reduces to the level where the water just reaches on the feet when you enter the well. When the level is reduced, the digger continues to dig until when the water level increases to the level of shoulders and then doesn't decrease anymore when pumping. When it reaches that level, then you have finished the work.[18]

Kuzibua can be dangerous work. It requires well diggers to pump water out while digging deeper, until the flow of water coming from the aquifer is at least equal to or more than the pump can manage. The aquifer must be excavated deeply enough that the water flowing from it reaches the shoulders, implying obvious risks of submersion if the level rises too quickly. Furthermore, because the well digger is inside the aquifer, alongside the pump, he may be exposed to toxic (petrol or diesel) fumes.

> The smoke is bad. It can make the digger suffocate. If you are not careful, you can even faint. The digger has to come out often to get fresh air. Also, you can find that the head can start paining after work. What most well diggers usually do is make sure they drink milk after work, to clear their throats.[19]

Well diggers use a rope with knots to climb out quickly in case the water 'explodes' (Figure 2). Alternatively, they may use an improvised belt tied to a rope so that they can be pulled up if needed: "When you are digging, you first encounter mud, then channels of water. This is moving water. It moves just like river water. There is usually the largest stream down there with a lot of water; when you reach it, it will explode. This why you need a [safety] belt".[20]

In addition to the rope or safety belt, there is a specially designed tool used for kuzibua work to make it safer: the *mchimbuo* or *mtalimbo* (literally 'iron bar'). While other generic tools such as spades and pickaxes are used to reach the aquifer, the mtalimbo is a local invention designed for digging inside the aquifer. Developing such a tool is grounded in an experienced understanding of how to get water to flow from the aquifer while minimising risks of bodily harm. The tool itself, in its material design, thus speaks about the materiality of the aquifer and how the well diggers learn about its nature and the liveliness of groundwater from digging inside an aquifer.

[17] Photo Narrative 1, Date: 5-03-2021.

[18] Photo narrative 3, Date: 26-3-2021

[19] Photo narrative 10, Date: 21-6-2021

[20] Interview Eliud Mathayo, Shambarai Burka, 12/02/2020

Figure 2. A well digger engaged in the kuzibua process holding the safety rope.

Source: Photo courtesy of T2GS Tanzania project team 2021.

Figure 3 show two different mtalimbos. They are made of iron and have a sharp end. The tool is used just like a chisel but is only employed once well diggers come across the cement-like layer that usually signifies that water is close. It is usually long, to protect the digger from the effect of the water that comes out forcefully. When using this tool, the well digger gets to dig while standing, so water cannot cover him when it comes out.[21] This is also convenient for the remainder of the kuzibua process, when the well digger finishes digging while the bottom of the well is covered with water.

It is clear from these accounts that frequent encounters with the aquifer have led to intimate understandings of its characteristics and behaviour. How the soil and water feel and appear during the digging process give well diggers precious clues about how to successfully dig for water and how to stay safe in the process. The well diggers we have talked with describe how the aquifer sometimes feels like mud, sometimes like cement, which can be harder or softer, and sometimes like hard rock. It also, of course, can feel like water, flowing with varying speed. It is the feel of rock and water that gives well diggers indications of whether and when the water will come out forcefully, so they can switch tools or take protective measures.[22]

For our third vignette, we return to the Rufaro community in Zimbabwe, and specifically examine what close encounters ensue when groundwater, pumped up through boreholes, is stored at the surface to supply an irrigation scheme.

[21] Photo Narrative 1, Date: 5-3-2021

[22] Though the well diggers will not use such terms, from their description of the composition of the soil, rock, and water flows, we can assume that the farmers draw water from a (semi-) confined alluvial aquifer.

Figure 3. Two types of mtalimbo.

Source: Photo courtesy of T2GS Tanzania project team 2021.

CONNECTING WATER, PEOPLE, SOILS AND SPIRITS – ZIMBABWE

In Zimbabwe, only a few smallholder irrigation schemes use groundwater as their primary source of water. The Rufaro irrigation scheme in the south-east of the country is one such scheme, allowing about 55 smallholder farmers to irrigate their crops for subsistence as well as for local markets. The Rufaro Irrigation community was established in 1983, soon after Zimbabwean independence, as part of a collective farming cooperative resettlement programme. The everyday governance of water in the scheme involves evolving hybrid arrangements, drawing on various bureaucratic and traditional sources of authority and on moral ecological norms. The irrigation cooperative has changed in form and function over time. Local traditional, elected, and government-appointed leaders have played a role in shaping water management, but government departments have limited reach. The management of the irrigation system and the infrastructure falls largely to the farmers. In this scheme, the groundwater is pumped from boreholes into a surface storage tank, and from there it is distributed to the fields through pipes, valves, and taps.

Whilst the groundwater is pumped up from boreholes drilled by contractors, more intimate encounters with this water are required to keep the system functioning (see Chitata et al., 2021, for a description of the tank-boreholes system). Nutrients dissolved in the groundwater form a feast for algae as soon as it flows into the daylight. To ensure these algae will not block the pipes of the irrigation system, the farmers need to periodically clean the storage reservoir.

Almost all of the water in the storage tank is emptied in preparation for algae removal – only a depth of about 15 cm of groundwater is left in the tank to make it easier to scoop and scrape the algae. For this heavy work, strong men among the farmers volunteer to get into the slippery tank barefoot using a self-made wooden ladder. When inside the tank, the men will scrape the algae from the walls and bottom and scoop it into buckets using shovels and hard brooms. They carry the algae-filled buckets up the ladder to the top of the wall, where other men will be waiting on the other side to carry the bucket down. The algae are disposed of just outside the tank (the buckets are too heavy to carry very far), and the empty bucket is returned to those who are inside the tank.

Removing algae in the tank takes a long time, as the surface area of the tank is quite large (350 m^2), and the layer of algae is thick. The men and their clothes become soaked with algae and water. Also, the slippery conditions in the tank call for patience to reduce chances of getting injured. As one of them narrates: "We have been here for six hours now, and this is not an easy task; it is slippery in here, and dangerous, but we have to do it even without gumboots".[23]

Figure 4. Farmers in the tank taking a break from scooping algae (right), and a farmer scraping the algae close to the ladder used to get into the tank and to take out the algae (left).

Source: Photos courtesy of Tavengwa Chitata 2021.

Even though this hard work is crucial to ensure the functioning of the irrigation system, it hardly gets noticed by those not involved in the activity, as it happens behind the high walls of the reservoir. When asked why these men voluntarily engage in these labour-intensive activities without much reward, one of them explains that: "When you get something from your ancestors, it is your natural duty and obligation to take care of that which you have been given, because the ancestors do not give fortunes more than once".[24] This reference to the spirit world is also offered when the farmers try to make sense of why sometimes the algae bloom more than at other times. The farmers in the Rufaro irrigation scheme believe that the appearance of algae in the storage tank is a communication from the water spirits that they have angered their ancestors. This anger might have several reasons, yet the farmers explicitly link it to pollution of the groundwater as result of the fertilisers they use. As one farmer explains: "This algae bloom is too much; we never used to have it so plenty. It is a sign that the ancestors and water spirits are not happy about what the people (…) are doing to the water or land".[25] The farmers show profound knowledge of the soil and explain how – through the cracks of the dry clayish soils – the water they use to irrigate their plots washes away the fertilisers and leaks back into the aquifer, causing nitrification of

[23] Interview with farmer 1 (F1)

[24] F22

[25] F27

the groundwater.[26] This nitrification of the water becomes more visible for the farmers through the algae blooms in the storage tanks.

The physical encounter with algae and water through tank cleaning functions as a process in which farmers learn about groundwater quality – developing understanding of how water, fertilisers, soils, and spirits 'behave' together. This knowledge, and the moral ecological meanings embedded within it, have also shaped their agricultural practices, as several farmers explained to us. In fact, many farmers have, as a consequence, reduced their use of chemical fertilisers in favour of manure and have also adjusted the irrigation times and practices to allow the water to slowly infiltrate the soil rather than flush away nutrients (Chitata et al., 2022). For example, farmers use a perforated 2-litre bottle fitted to the end of a reinforced steel horse pipe and placed on top of a grass mulch. This reduces the erosive force of the water and the volume of water that will drain directly underground through the cracked soil points.

DISCUSSION

In each of the three encounters described above, the engagement with the aquifer and with groundwater is achieved through hard physical work. This labour-intensive work, undertaken with low-cost tools, is often hidden and little reported through official channels. As a consequence, it may appear to be less important and impactful compared to the larger scale, more technical and commercial siting and drilling of boreholes, or professionalised management of irrigation systems. We contend, however, that this work is significant in a number of ways. It generates contextualised knowledge of groundwater and aquifers, enabling local economies of groundwater and irrigation to emerge, develop, and operate. This happens, for example, through monitoring the depth of wells, enabling affordable access to reliable groundwater for rural communities, and raising local awareness and understandings of how fertiliser use impacts groundwater and its lively capacities. The labour involved is onerous, sometimes risky, and mostly conducted by men. But it is also, we argue, a fundamental feature of emerging rural groundwater economies and encapsulates the tensions between development and sustainability that they entail. In each of our three vignettes, the work undertaken has clear practical implications for local agricultural production and the potential for sustainable transformations. In this section, we explore these points in more detail, to highlight some of the costs and benefits of these embodied encounters and why they matter.

Embodied encounters: Hard work, risks, and taking care

The work that we detail here is embodied in different ways and involves control over physiological processes and emotions, strength and stamina, and the management of risk. Intensity and duration are significant to the experience of this hard work. In the case of the Zimbabwean prospectors, generating an encounter with groundwater involves the strenuous physical activity of producing adrenaline and holding the Y-stick "firmly against its pull", while maintaining extraordinary concentration for the time it takes to locate the water. The well diggers in Tanzania must have the physical and mental capacity to dig through layers of rock and soil in order to find water and then have sufficient stamina to work further, inside the aquifer, to deepen the well. And the accounts of the farmers emphasise the hours and hours spent clearing and shifting algae in the slippery, stinky tank, in the heat of the sun.

Hard manual work involves confronting and managing risk. There is always the risk of physical injury – of sustaining groin and hand injuries (the prospectors); of being drowned by sudden bursts of water when penetrating the aquifer or suffering illness by inhaling exhaust fumes from water pumps (well diggers); or of slipping on algae-coated surfaces (the tank cleaners). Protecting against these risks to themselves and others involves the workers being attentive to the environment, taking remedial measures like resting and drinking milk, and using appropriate tools and safety arrangements (a pump,

[26] F8, F19, F3

belts, ropes, and steps). In the case of well deepening in Tanzania, the adapted tool used is not only sufficiently tough to do the job of breaking through the rock, but also long enough to protect the well-digger from suddenly being submerged. In other words, close encounters with groundwater and the aquifer require the workers to take care of themselves and their colleagues.

In these accounts here, we have emphasised the hard physical work involved, but there are also hints of positive feelings about the work in terms of pride in expertise or a sense of obligation to family and communities, the natural and spirit worlds. Our cases, then, illustrate that hard physical effort can be seen as burdensome but also rewarding. It is significant that this work is entirely undertaken by men. As well documented elsewhere, much agricultural labour is provided by women (e.g. Hajjar et al., 2020; Pattnaik and Lahiri-Dutt, 2021), yet men often take up roles that offer them status in the community and/or financial gain, as indicated in our vignettes. Questions then arise as to how such water work is understood and valorised in the communities studied. Following points made by Jackson (1999, 2000), we could pose questions about how perceptions of the costs and benefits of such work are linked more broadly to gendered divisions of water and agricultural labour. Does the dominance of men in prospecting, digging, and maintaining, as detailed here, further marginalize women within emerging groundwater economies and undervalue their labour and embodied knowledge?

Situated encounters – Socially located and moral ecological

Knowledge of the aquifer and of how groundwater 'behaves' is gained practically through the hard physical work of prospecting, digging, and cleaning. But this practical knowledge does not exist in a vacuum; it is located and generated in engagement with the social-natural context. The examination of embodied encounters helps to reveal the ways in which practices are shaped and knowledge generated in the light of the logics, orientations, and beliefs that people draw on to situate themselves in relation to others and to the natural world. These 'moral-ecological' understandings play a role in providing explanations for environmental phenomena by placing these within wider frameworks of cause-effect linkages. They also offer explicit and implicit understandings of proper hierarchies, just distributions, and moral ways of behaving, so maintaining or challenging social and hydrological orders. So, for example, the Zimbabwean prospectors take an active position in maintaining some sort of water balance in the emerging groundwater frontier by monitoring the depth of boreholes. Notably, they do not charge community members for their services. Through these acts, we could argue that they are upholding a commonly held view in Zimbabwe that all should have access to natural resources, particularly water (Derman and Hellum, 2007; Shoko and Naidu, 2018). Furthermore, their actions maintain the idea that accessing water is the proper domain of community norms, not just individual entrepreneurial actions. This could be significant in shaping the way that local groundwater economies emerge and are negotiated locally. In the case of the Tanzanian well diggers, it would be impossible for so many farmers to access relatively cheap wells and to expand and intensify their production, potentially transforming poor rural communities by boosting the local agrarian economy, without the hard work, inventiveness, knowledge, risk-taking, and skills of the well diggers (Komakech and de Bont, 2018).

As part of the moral economy, the work that prospectors do for free in their community may also bring benefits to them in terms of reputation, respect, and entitlement to resources. For example, the borehole owners may feel indebted to the prospectors and therefore offer them free access to water. Similar entitlements are gained through the undertaking of other 'free work' in communities. For instance, in the case of the Rufaro irrigation scheme, a crisis arose when the boreholes broke down during Covid-19 lockdown and no government technicians were available to fix them. In this case, the community asked the artisanal miners (mining illegally in the area) to undertake the necessary repairs to one borehole. As a result of doing so, the miners were granted access to water supplies that they had previously been prohibited from using (Chitata et al., 2023).

In the case of the irrigation farmers cleaning the tank of algae, the knowledge gained through their labour is shaped by moral ecological explanations. In these, the algae are a sign that ancestral spirits are displeased by the mistreatment of soils by the farmers. As a result, the farmers have reshaped their agricultural practices to use less commercial fertiliser and instead rely on locally available manure. Physical labour and the knowledge deployed and generated through it thus has the potential to shape access to water and agricultural practices in subtle yet significant ways.

Making work with groundwater visible

Groundwater and aquifers are, by their physical nature, often partially invisible and elusive. As we have seen, the work undertaken to access them is also often hidden or easily overlooked. We argue here that it would be a mistake not to closely scrutinize such encounters, given the insights such scrutiny can yield into how people come to understand the liveliness of water and how their labour has the potential for shaping people-groundwater dynamics and local rural economies.

Whilst the work of the prospectors, well diggers, and farmers that we detail here is intense and physically demanding, it may remain relatively invisible to outsiders. The uninformed observer might see a prospector holding sticks or divining rods but be unaware of the struggle for internal control and connection with groundwater that is being played out in the divining process. Well diggers conduct much of their work down the well in remote fields, often even physically inside the aquifer – the labour they do, the care they take to deliver groundwater to farms, and the risks they face are directly observed by few people. And the farmers cleaning the tank are hidden inside the concrete structure.

Drawing attention to the often-hidden processes of water work clearly reveals the care that prospectors, diggers, and farmers take to manage and make groundwater flows available for agriculture. This care for water flows from the aquifer to farmers' fields is premised on hard and risky physical labour. In this way, we argue, locally hired or volunteer groundwater workers play a central role in driving and sustaining much of the rapidly growing groundwater-based agricultural development in sub-Saharan Africa. In cases such as those documented here, without the embodied knowledge of prospectors, diggers, and farmers, the local aquifer and properties of the groundwater would be little-known in the communities.. Without low-cost, labour-intensive solutions to accessing and maintaining groundwater flows, irrigated agriculture would not be feasible for many smallholder farmers but the preserve of those who can afford more expensive technologies. Hence, making groundwater work visible can provide insights into how local farmer-led groundwater economies emerge and the shape that they take.

While we focus here on the importance of learning from locally situated encounters with groundwater, we do not intend to romanticise local practices and their outcomes. In addition to the benefits identified above, they carry costs to individuals and communities. For example, the knowledge generated may accumulate in particular (men's) bodies, making them local experts on groundwater, and as such giving them advantaged positions in deciding locations for groundwater abstraction, shaping irrigation practices and opportunities for financial gain. Externally produced models and formal hydrological and technical knowledge about how to access and distribute groundwater may well be useful and sought after in the contexts that we discuss. Our intention here is to add perspectives on groundwater management and governance in the light of urgent development and sustainability concerns surrounding irrigated agriculture in sub-Saharan Africa. What ties our examples together, which is also our key point, is how locally situated groundwater knowledge is produced and shared through hard physical groundwater work in specific moral, cultural, and social-ecological contexts. That this knowledge production also shapes groundwater use trajectories implies a potential point of engagement and learning between externally sourced interventions grounded in formal geo-hydrological knowledge and local situated practices and expertise (Årlin et al., 2019).

CONCLUSION: KNOWING GROUNDWATER – EMBODIED ENCOUNTERS AND EMERGING GROUNDWATER ECONOMIES

In this paper, we have used three vignettes of close encounters with groundwater to describe the work involved and the knowledge produced in accessing and caring for groundwater. The insights offered here are significant in two ways.

First, the cases presented contribute to building a picture of how knowledge about groundwater is generated through hard physical work in particular locations and what the nature of that knowledge is. The cases show how such knowledge is generated in the interplay between the body and the workers' physical encounters with and perception of the environments they are working in. Frequent physical interactions with groundwater and the aquifer generate rich and intimate understandings of the changing quality and quantity of water flows. These encounters become primary ways in which people in communities come to know about the dynamics of groundwater. The knowledge generated in this way is not simply technical, or limited to understanding physical processes of water flow, seepage, recharge, and nitrification. It is also infused with moral ecological ideas about proper ways of doing things, rightful allocations, and caring for the self, others, and the environment.

Second, the examples explored here offer some insights into how local groundwater economies are enabled and shaped in distinctive ways. The embodied encounters that we detail all involve relatively low-cost solutions to accessing and caring for groundwater. A common theme in our cases is the inventiveness and adaptation involved in the practices deployed by communities where more sophisticated siting, drilling, and maintenance solutions are out of reach of the majority. Though apparently mundane, and often going relatively unremarked, these encounters have the potential to quietly shape broader socio-natural relationships in emerging groundwater economies. Potential impacts include the opening up of access to groundwater (and hence irrigated agriculture) to more farmers and which may shift the balance between private and communal use, or between irrigators and those previously limited to rainfed agriculture. Further, enabling more access to water has likely implications for groundwater levels and recharge processes, for agricultural practices, and hence for broader processes of economic development and environmental sustainability.

In the global context of efforts to both promote the intensification of agriculture and to manage water resources sustainably, the low-cost, physically intense encounters of those enabling groundwater access to farmers in local contexts is worthy of note. The call for pluralising groundwater knowledges to tackle difficult sustainability problems and development challenges is in essence a call for sharing knowledge models across different realms of expertise (Zwarteveen et al., 2021). Documenting and communicating experiences of largely overlooked, embodied encounters and hard manual work with groundwater and the understandings, skills, development, and the concerns that they generate isa necessary task for addressing this agenda.

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