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From Divine to Design: Unearthing Groundwater Practices in Tamil Nadu, India

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ABSTRACT: This paper describes two common groundwater logics in Tamil Nadu: that of dowsing and that of modelling. Both rely on intimate knowledge and great dedication but have legitimacy and status in different communities. Groundwater experts celebrate and value modelling for assessing well and aquifer conditions, but – at least when among peers – dismiss dowsing logics for being 'non-scientific'. Farmers and others interested in digging and drilling wells, on the other hand, routinely call in the help of dowsers, or water diviners, for determining well locations (and often depths). Rather than entering the science-dowsing controversy, this paper starts from the observation that modellers indubitably make use of the wisdom of dowsers: they use known well locations and depths to make their predictions more accurate and sensitive. This is why we think it is worthwhile to assess the practices of both in a more symmetrical way. For this we engage in a care-ful comparison of these two ways of knowing, showing that despite their differences, modelling and dowsing have many things in common. Both require years of education and training, and both modellers and dowsers take pride in being meticulous and insist on the need for repetition and fine-tuning to perfect their routines – that is, to mathematically represent aquifers or magnetically sense groundwater flows. So, does dowsing or divining as a 'beyond scientific' form of knowing have something to offer when it comes to sustainable groundwater governance? The ways in which a water diviner practises care – seeks to improve farmer livelihoods, gets compensated, and senses the right place for a well (which is not about whether you could, but also whether you should dig at a certain location) – suggests that this may be so.

KEYWORDS: Groundwater knowledge, dowsing, modelling, care, prediction, Tamil Nadu, India

INTRODUCTION

Tamil Nadu, like many Indian states, depends heavily on groundwater for domestic, industrial, and agricultural purposes. Depletion, observed through dropping water levels and drilling deeper wells, as well as the ensuing conflicts, has been well documented during the last decades (cf. Reddy, 1989; Folke, 1998; Janakarajan and Moench, 2006; Narayanamoorthy, 2015) – as have been proposed interventions to change this momentum, such as tank rejuvenation or creating recharge shafts (cf. Sakthivadivel, 2007; Shah, 2008; Senthilkumar et al., 2019). These interventions notwithstanding, there is continuous reporting of grave over-extraction in hard, arid rock areas like the District of Dharmapuri (Chinnasamy and Agoramoorthy, 2015). Also in the alluvial Cauvery or Kaveri Delta,[1] there are indications that farmers continue to drill deeper wells (Agrawal et al., 2022).

While pathways to sustainable groundwater use are high on academic and policy agendas (Srinivasan, 2019), "predicting India's groundwater availability" is an (increasing) challenge for scientists (Chinnasamy and Agoramoorthy, 2015: 2140). This is because they are faced with a data problem. There is, some scientists say, not enough suitable and trustworthy quantitative data, fewer monitoring points and systematic data collection over time following government withdrawal, as well as more problems in obtaining data from government agencies (ibid; see also Hora et al., 2019; World Water Quality Alliance, 2021). Making models, and predicting where and how much groundwater is available, is thus (and has been) a practice of mediating knowns and unknowns.

While modelling, in India and globally, is commonly used to understand groundwater systems and guide decisions on groundwater governance and management (Howard et al., 2010), farmers on the ground and others interested in digging and drilling wells use other methods to find out about groundwater availability and well location. It is at this point that our story starts. Four of the authors[2] – an anthropologist, a Tamil native water development professional, a hydrogeologist, and a socio-hydrologist – were involved in a research project that set out to anticipate and influence change and transformations in the Kaveri Delta by studying, socially and technically, its surface and groundwater flows (Srinivasan, 2019). This paper describes our experiences with groundwater modelling and ties these to our ethnographic work with water diviners.

Conceptually, this research connects to others working in the discipline of science and technology studies (STS) who are critical of treating scientific ways of knowing as the only ones that generate tenable or correct knowledge. Truths in this body of thinking are not universal (Law and Mol, 2001); they are 'being done' – and have validity – within specific networks of actors and practices that enact them (Mol, 2002). Our work in this paper, then, consists of symmetrically analysing the practices of modelling and divining by ethnographically exploring the heterogenous (local) networks of people, tools, methods, traditions, and languages of prediction (or expertise) in which they occur. We refer to these networks as 'logics'. STS researcher Annemarie Mol (2008: 8) explains 'logics' as the discourses embedded in practices that can help to disentangle not only the different orderings of socio-material elements but also the 'rationality' of these practices – be they modelling or divining.

Hence, rather than treating modelling as separate from politics and society (and therefore scientific and 'right') and divining as merely folkloric and ritualistic, we approach both knowledges as entangled

[1] The name Cauvery – Delta or River – is the anglicized version of the Kaveri and was introduced by the British. In this paper we use Kaveri Delta, to stay closer to the Tamil language and pronunciation of their sacred river.

[2] We the authors are a transdisciplinary team. Author roles and contributions in brief are: Andres Verzijl (anthropologist), the main researcher of the paper, co-researched the dowsing practices and gave feedback on model development; Vivek M is a Tamil-speaking professional from Dharmapuri who interviewed most diviners and was involved in data collection for the model; Ankita Prayag (hydrogeologist) is the principle modeler of the project; Veena Srinivasan is the senior socio-hydrologist who helped develop and improve the model; Carolina Domínguez-Guzmán and Margreet Zwarteveen participated in the conceptual thinking, writing, and redrafting of the paper. In this paper we do not use our own names or those of the persons we worked with.

with culture. This symmetrical form of analysis is inspired by and embedded in work done on care. In particular, it builds on proposals to use initial assumptions about how the world is ordered with care and caution. Rather than using such assumptions to describe and diagnose people, traditions, and knowledges as different or even as lacking or deviant, a 'care-ful' comparison (see Law, 2021) starts from the premise that all logics and principles are interesting and worthy of attention on their own terms (see also Mol, 2008; de la Bellacasa, 2011; Michael, 2017). Carefully comparing different groundwater practices therefore does not set out to rank different logics, assessing which one is better or superior, nor is it about romanticizing one while exposing the other as wrong or evil. Our 'care-ful' approach, taking after John Law's (2021), is one that does not try to make commensurate or to homogenize, nor does it prefer one logic or language – for instance because it is more rational or scientific – before engaging in the comparison. Instead, it tries to accept and stay with differences and remain attentive to equivocations (Viveiros de Castro, 2004; Yates-Doerr, 2019), using these to begin multiplying worlds – or, in our case, groundwaters – and thereby potentially expanding the repertoire of imaginaries for defining, being with, or relating to groundwater.

Methodologically, this research is the product of the COVID-19 pandemic, which saw most of us working from home offices in the Netherlands and Bangalore and one of us operating from a small field station in the delta. This led to the paper becoming a product of co-research and co-creation of qualitative data (see Mol, 2008; Verzijl, 2020), centred around often-inspiring weekly online meetings where anthropologists and hydrologists listened to the accounts collected by the field team and contributed to each other's research work. It is doubtful whether similar insights to the ones described in this paper would have been obtained with the short field missions that were planned pre-covid. For the water divining and dowsing practices, we interviewed five diviners from Dharmapuri District and the Kaveri Delta[3] and cross-checked the interview data with farmer accounts in both areas. We observed and recorded dowsing practices and were allowed to follow a diviner when he went to find groundwater flows for a client. For the modelling work, we drew upon our own experiences of building a numerical model and used reflective conversations amongst ourselves to better grasp how this was done.

Over the span of 20 months, we found that these two groundwater logics of modelling and divining have a lot in common in terms of how they are being done. This invited us to reflect on how these two quite distinct forms of knowledge can be put into dialogue, while keeping their differences alive. We therefore produced two sections about predicting groundwater: by modelling in section four, and by dowsing in section five. This is the core of the paper. To do a symmetrical interpretation and analysis of these logics, we devised a simple schema made up of codes that we identified as part of our analysis. These codes help characterize, situate, and contextualize each logic in the following terms: talent, training, tools, trials, and thoughtfulness. In the final section, we use these terms to compare both logics, as doing so helps usefully blur oft-used distinctions between modern and non-modern (or scientific and traditional) ways of knowing and reveals their interdependencies. First, however, we will detail how our modelling started, how we got interested in divining, and how we worked around the tensions that in some other (scientific) spaces exist between the two.

HOW MODELLING MET DOWSING

One of the focal points of the team was to understand, (geo)hydrologically, the water flows through the Kaveri Delta, as farmers indicated on our subsequent field visits that quantities of both surface and groundwater were declining and that they had to invest in new and deeper wells. Having an experienced socio-hydrological modeller and a motivated hydrogeologist among us, we started modelling the history

[3] The Kaveri Delta was the project case study site where we had our first encounter with a diviner. The choice of Dharmapuri was pragmatic. During the pandemic lockdowns, one of the authors sought out diviners in and near his hometown to further our exploration of this practice.

of surface-groundwater interactions in the delta in order to discover trends or patterns (see Prayag et al., 2023). Designing this model obviously required specific experts, but also crucial data sets, necessary equipment (in this case a fast laptop with MODFLOW software), and – emphasized by the socio-hydrologist – local socio-environmental knowledge (see also Srinivasan et al., 2017).

After the largely theoretical and digital exercise of conceptually visualizing the delta, we ran into similar data collection problems as the ones that Chinnasamy and Agoramoorthy (2015) describe. The information we solicited from the Tamil Nadu Public Works Department (PWD) and the Indian Central Ground Water Board (CGWB) turned out to be very rough estimates. Other monitored borehole data (amount, location, and depth) were not readily shared or made available to us. This was a big concern. Simply put (in modeler terms, that is): fewer borehole data points mean reduced model accuracy, which means less reliable predictions of groundwater flows.

In response to these data issues and having the aspiration to improve the model in the future, we initiated a citizen science campaign to record GPS location, groundwater level, salinity, soil type, and bore depth (Agrawal et al., 2022; see also World Water Quality Alliance, 2021). At a few sites, we also thought to utilize borehole sensors to crosscheck, to the extent possible, the CGWB dataset. In January 2021, members of the project team, including one of the authors, visited the Peravurani sub-district in the Kaveri Delta to install these sensors. Because of the cost of this precision instrument, the borewell owner needed to be a trustworthy person. We asked the leaders of KAIFA, a farmer association in Peravurani, for help, and between two sensor installations, the team waited at the house of one of the leaders.

While waiting, we asked who determines the location of these wells and how, or by what methods. Not at all surprised by this question, the leader made a quick phone call to a water diviner or *neerottam pakkaravar* (*neer* = water, *ottam* = spring/flow, and *pakkaravar* = finder). Apparently, this person, named Krishnan, was an acquaintance and lived nearby. He soon arrived at the house, where we asked him about his craft. He explained that finding waterflows is an ancient practice in Tamil Nadu. Krishnan uses a lemon to pinpoint the spot where one should unearth water. Lemons, like neem sticks, coconuts, rods, and pendulums, are common flow-finding equipment in Tamil Nadu. But tools like a lemon are not all he utilizes. In determining the site, Krishnan says, termites are a sign. It is known that these animals build their mounds in areas with moisture in the ground – or even flowing groundwater. Moreover, to know if a particular location is the right place to dig or drill a well, he says, "First I will go to the spot and see if there is any negative force or if the borewell can be drilled. At the same time, I also will look through the *panchangam*".[4] Only then will Krishnan conclude whether that place is auspicious and suited for a (bore)well.[5]

Krishnan's methods correspond to those mentioned by Dr S.V. Subramanian (1980), who compiled a book in Middle Tamil (as opposed to the Tamil spoken today) that contained "Tamil treatises on the science of well-divining".[6] Reading and analysing historic palm scriptures, he mentioned several ways or methods of finding water underground that are "as old as the culture" of the Tamil peoples (ibid; p. *v*). Three of our team members wrestled with this Old Tamil text. In it, they identified several divining methods that can basically be categorized into two groups. The first one refers to the use of the

[4] The panchangam is an astrological calendar and almanac that is widely used in rural Tamil Nadu, for example in marriage affairs, but also to make predictions on annual rains or when (and what) to plant. It is consulted in a lot of daily activities and practices. For instance, while researching a local tank revival movement, we found that the panchangam was also consulted to determine the best time to start tank restoration works.

[5] This encounter sparked our interest in further pursuing the practices and meanings of water divining. Interestingly, some team members were initially a bit reserved, even a bit smirky, not really expecting this to be serious groundwater research. And yet, several had had direct dealings with diviners and divining practices before and – as it turned out – relate to and engage with them easily.

[6] This is the title of the English introduction. The book's title is *Kuva Nul.* It was difficult for the team members to translate in detail because of how much the text of the palm scriptures collected in the book differs from contemporary Tamil. Three of the team members – including the second author – went through it to capture the general lines of the treatises.

panchangams or almanacs; the second is about what they called the 'appearance of the field' – how to find underground flows by knowing different soils and "plants and animal characteristics of a particular place" (ibid; p. *vii*). Surprisingly, the scriptures do not mention a third category, which is the use of instruments or tools like rods, sticks, coconuts, and lemons.[7] The experts in flow finding, according to Subramanian (1980), are called *calliyar*, meaning those who do "the prediction of what is there underneath the earth" (p. *vi*).

TENSION BETWEEN TWO TALES

Intrigued by Krishnan's stories and divining practices in the delta, we also contacted dowsers in another hydro-geological area: the hard rock District of Dharmapuri, where one of the authors is from. Its predominantly charnockite and gneiss rock formations (Chinnasamy and Agoramoorthy, 2015) are different from the alluvial delta, which translates into different groundwater presence and flows. In Dharmapuri, water flows through fissures and cracks in the rocks, while in the Kaveri Delta water moves slowly through the alluvium material of the (un)confined aquifers. Borewells in Dharmapuri tend to have a much lower yield, and pumped water is often stored in older large-diameter open wells that are no longer in use.

Groundwater divining is common in both case study sites. Following a few quick surveys, we feel confident in saying that the great majority – in some villages the local farmers estimate over 90 percent – of well owners in both Dharmapuri and deltaic Peravurani have been using diviners for generations to ascertain where and how deep to dig or drill their (bore)wells. This suggests that there could be hundreds, if not thousands, of groundwater diviners like Krishnan in Tamil Nadu, given that there are over 12,000 *panchayats* (local government councils) in this state, each consisting of various villages which together have over 1.5 million working (open and tube) well.[8] It boggles the mind that the Tamil groundwaterscape and groundwater scene is formed and transformed by mobilizing neem branches, lemons, and almanacs. The presence of these dowser-found wells allows and is crucial for the development of groundwater models and aquifer management plans. After all, existing wells are used to assess groundwater behaviour and improve model accuracy: 'from divine to design', indeed. But in engineering and hydrogeologist expert circles, and the talk about groundwater that they generate, you hear little about diviners. They are crucial but absent.

This absence of dowsers is reminiscent of a story by Callon and Law (2004), based on an illustration from one of Callon's old schoolbooks with the captioned adage: "Invisible but present beside the ploughman is the blacksmith who made his ploughshare". It is meant to convey that beyond his field, the ploughman "shares his life with many other people and things" as part of a network "extending into other places and times", and even other worlds (2004: 6). In our case, the blacksmith is the diviner, and the field is the office spaces out of which (serious and scientific) groundwater knowledge comes. The well is the ploughshare: an object-multiple that connects the hydrogeologist, her laptop, and satellite data to the almanac's celestial data and the lemon of the diviner. But while in the schoolbook illustration the blacksmith accompanies the ploughman, "his silhouette surrounded by a blue halo, just like a guardian angel" (p. 6) or positive force, the groundwater experts have a mostly negative take on diviners.[9]

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[7] Woodhouse (1991) mentions, for the area around Kibwezi, Kenya, that observing and interpreting natural indicators is important in finding (shallow) groundwater and that this is used in combination with forked sticks/branches. He estimates the success of the local people using these methods rates at 70%.

[8] A modest estimate based on Janakarajan and Moench (2006: 3979), corresponding to an average of 11 wells/km^2.

[9] See, for example, https://www.indiawaterportal.org/questions/traditional-groundwater-divinersdowsers-vs-science-and-technology-groundwater-exploration, accessed 15-01-2022. It gives a nice impression/opinion of someone who thinks dowsers are backward and unreliable. Also, in 1917 the US Geological Survey published a report which assumed its readers to "appreciate the practical uselessness of 'water witching' and other applications of the divining rod (…) and it should be obvious to everyone

The reason for this – or one of the reasons – is not their success rate. We suggest that in certain hard rock and fissure areas (especially at deeper levels), geoelectrical methods are themselves not reliable, while in alluvial aquifers like the Kaveri Delta, both diviners and hydrogeologists might be equally and as often successful. [10] Perhaps the reason for the depreciation of dowsing has to do with the incommensurability of scientific knowledges with water divining knowledges. Despite attempts to offer explanations for what dowsers do, science is unable to verify dowsing logics. Dowsing can be said to be a way of knowing groundwater that exceeds science. We posit that this is not a valid reason not to treat dowsing seriously as a way of knowing. On the contrary, such knowledges (and the practices in which they emerge) may yield new understandings – for instance, about what water is, or about how to be with water – that can be insightful for addressing existing concerns (see also Verzijl et al., 2019; Domínguez Guzmán, 2021). What we therefore would like to do in this paper is to not use one logic – that of science – to explain the other – that of dowsing (or vice versa). Instead, we make an attempt to treat the stories of the diviners and our reflections on modelling in a symmetrical way.

From the above we can infer that modellers as well as diviners rely on in situ or local environmental information; mobilize different equipment and tools; and rely on tabulated data when doing what they do. Both hope to understand groundwater and aim to forecast where and how it flows but do so through different ways of knowing that are invisibly but intimately entangled. In the next two sections, we describe this art of predicting, according to two different logics. We do this through a simple heuristic list: talent, training, tools, trials, and thoughtfulness, which we mobilize for each logic.

THE ART OF PREDICTING: BY MODELLING

It was August 2022. In an apartment somewhere in Mumbai, our modeller, Sneha, was feeling relieved and happy. She had just got off the phone with one of India's most renowned hydrogeologists, who worked as a technical advisor to India's Central Groundwater Board (CGWB) and drafted the methodology Sneha used for her model. She had contacted him in despair after heated discussions amongst the team members about model validity and its running on lump data (a single entry for a large unit of measurement; in this case, a single value for water in- and outflow for a large area). In modelling work, the smaller the area unit is, the more accurate the prediction will be.

The advisor to the CGWB acknowledged the granularity problem with the water budgeting data but told Sneha she had made the right choice in using this data set, as others are not readily available. He encouraged her to move ahead with her publication. Reassured and seeking support from the other team members, she submitted her article to a prominent journal. For Sneha, this was a very important moment. Publishing her model marked the closure of a period in which she sought to both improve the situation of Tamil farmers and develop the skills she needed to pursue her goals in life.

Three years earlier, she had enrolled in a Dutch water education institute to hone these skills, getting training in groundwater modelling and becoming a hydrogeologist. Sneha had travelled to Delft, in the Netherlands, in 2019 to pursue her career, but her journey had started even earlier.

Talent and training

At age 16, Sneha took several IQ and aptitude tests to determine what career she might be good at. In secondary school, she had always excelled at scientific subjects and was at the top of her class in maths.

that further tests by the United States Geological Survey of this so-called 'witching' for water, oil, or other minerals would be a misuse of public funds" (Meinzer, 1917: 5).

[10] In alluvial soils, water is distributed more uniformly than in hard rock (fissures). People in the former do not cont(r)act a hydrogeologist. The team contemplated how diviners may have regained their lost relevancy in this age of overextraction. Once water levels drop below 600 feet, the commonly used, economical geo-electrical methods (in particular electrical resistivity methods) do not work well; the resulting interpretations are ambiguous (Singh, 2003; see also Hasan and Shang, 2022).

"I liked numbers", she says. "You get the satisfaction of simplifying things and come to an answer (…) seeing yourself get the evidence". She contemplated the other courses: political questions were really hard (open-ended and tricky) and geography as it was taught was vague. On the other hand, math was clear, and she had a knack for math that most people did not.

Following the tests, an assessment team advised her (and her parents) to go for an engineering education. Even though Sneha did not at all aspire to be a groundwater modeler, the caste-based affirmative action policies of the Indian education system meant she was pushed in that direction twice. Instead of computer engineering, her first choice, she had to settle for civil engineering. And for her specialization, she had to let go of structural engineering to follow the water resources engineering track instead.

It took her four years of technical training to obtain her bachelor's degree. Sneha did her thesis project with and subsequently took a job at CTARA-IITB, a branch of the Indian Institute of Technology Bombay. She worked on water conservation interventions, assessing their utility in terms of increasing groundwater recharge and baseflows in rural Indian villages. During this time, she was under the tutelage of a charismatic professor who Sneha says was a source of inspiration in terms of her approach to the field(work) and working attitude. "He is my guru", she says, "and encouraged me to work on groundwater".[11] They would converse about Sneha's work and how to solve the many unknowns of water underground. The professor's research interests included algorithms, combinatorial optimization, and mathematical programming. It was he who advised and supported her going to the Netherlands to be trained as a modeller of, and thus mathematically represent, groundwater. Her chosen electives in Delft included courses like Hydrogeology; Groundwater in Adaptation to Global Change Impacts; and Groundwater Data Collection and Interpretation. Of particular interest was the Applied Groundwater Modelling course in which Sneha was introduced to MODFLOW, the code she would use to develop her Kaveri Delta numerical model (steady state and transient). Following these classes was hard. Amidst coronavirus curfews, she solved questions about modelling by scouring the internet. She prevailed and graduated in May of 2021. After all her arduous work, she emerged as an expert in groundwater prediction.

Tools and trials

After graduation, Sneha returned to India, where she would further develop the model which was her thesis topic. For this she could count on continued support from her thesis supervisor and was guided by the team's socio-hydrologist. Both of them had decades of modelling experience that she relied on during her work. Sneha's principal tool was a 14-inch HP Pro-book. On this laptop she would run countless MODFLOW simulations. MODFLOW is a computer code, or a set of mathematical equations, for "predicting groundwater conditions". It is a free tool created by the USGS,[12] but the application software, meaning the program where you must input the data and visualize the results that are calculated by MODFLOW code, can cost thousands of dollars. Sneha uses Groundwater Modeling System (GMS) software, for which she luckily obtained the license key from one of her professors. The laptop and code, together with some tables or desks, were the tools of this modeller.

When she started GMS, Sneha created a project file wherein boundary conditions and number of cells are defined. (Her Kaveri model consists of 25,000 cells of 1000x1000 metres.) Once other parameters like

[11] Sneha explains that in the Indian context the guru-sishya (teacher-student) relationship – though often religious – refers to an inspirational mentor who helps the student find her or his path. It includes supervision and guidance to find one's aims and support to go out there to realize them (see also Chandran, 2007).

[12] MODFLOW was developed by the USGS (United States Geological Survey). Quoted from the USGS website, it is a "modular hydrologic model (…) [which is the] international standard for simulating and predicting groundwater conditions and groundwater/surface-water interactions". See https://www.usgs.gov/mission-areas/water-resources/science/modflow-and-related-programs (accessed 17-11-2022).

recharge and abstraction rates, number of wells, rainfall and climate information, and derived geological and soil data were added, Sneha tried running the model for the first time – that is, starting to calculate the groundwater conditions for each cell and aggregating these. It was not easy to get to a satisfactory transient model; it involved many discussions with team members and supervisors and some creative search work on Sneha's part, to which we will come back in the next section. However, says Sneha, most of the time behind the laptop "was spent on model calibration (…) to make it sensible, make it real".

Calibration, Sneha explains, is the process of changing or tweaking the model parameters, such as "evapotranspiration, discharge, well abstraction, or recharge – and checking the results after running the model, in particular the R-squared".[13] Each time, you change only one value of one parameter. You try, adjust, run [the model], check, and try again. She continues: "For example, in the Vennar Delta[14] there are patches of red soil (…) [tabulated by her as model inputs] (…) you assign a recharge rate to these patches [or cells] (…) for example 1 metre/day. You know this is too high, so you make it 0.1 metres and then check again". It is trial and error. There are many parameters and inputs, and in this instance, she repeated the calibration steps over and over again. When asked how many trials she performed, she sighed while letting out a laugh. "Countless", she said, "but thousands for sure". During a full day, she would adjust, run, and check the transient model up to 30-40 times. Running the model took between 5-15 minutes each time, which implies 7 hours of waiting. Sneha spent waiting time by roaming the house, working on her paper, cooking something, doing some job hunting, or streaming a series. "It takes so much patience", she says. But it never frustrated her in the same way as did the patience she had to muster to gather the input data sets for the model.

Data collection problems made Sneha anxious at the start of her project.[15] Professionally, she felt she had a lot riding on this model and needed quality data. At several times during our discussions, she uttered that famous hydrological modelling dictum, "Garbage in is garbage out". To obtain better data, Sneha and the team contemplated several possible approaches.

Thoughtfulness

The granularity problem was always a concern. "A typical Indian thing", said Sneha. "Ideally, the government should have this data, like in any developed country you have [this]". Contemplating ways around this issue, she was advised by the team's socio-hydrologist to use Landsat imagery and LU/LC[16] data to reversely calculate abstraction rates at a more local level. The idea behind this attempt was that since a) land use type and crop choice were known (from our earlier project work) and b) we had purchased canal flow data, it was possible to determine how much groundwater was used in a particular cell. It was a creative way of 'making do' with what the team had, and of remedying the imprecise water budgeting data, but "very laborious". In the end, it did not work; "The model was showing dry cells", Sneha explained. These were invalid units where the abstraction was so high that values were beyond set model input. To improve the model, the team, thinking laterally, found another way. Sneha inserted geological maps (that the team found in existing documents) into her GMS file simply by tracing their lines instead of importing a database. Both attempts are not unheard of, but we make them explicit here to show that tinkering is a practice inherent in modelling.

Another concern was the relatively small number of wells with suitable data. When running the model, this computed to unrealistically large cones of depression because the water budget per cell remained

[13] In modelling, the R-squared determines the accuracy of how close the computed head (i.e., the calculated groundwater flow) comes to the observed head.

[14] The Vennar Delta is a part of the Kaveri Delta that has large saline areas (see Prayag et al., 2023).

[15] We mentioned this in the opening paragraphs of this paper (see also Chinnasamy and Agoramoorthy, 2015).

[16] LU/LC, or Land Use/Land Cover data, is usually informed by satellite imagery and remote sensing; it tabulates, or visualizes, how much of an area is covered by which crops or other type of land use (forests, urban areas, fallow lands, etc.).

the same. One of the ways to remedy this was by adding the locations of more wells. The team undertook three actions to that end. First, Sneha found an old shape file from the NASA Socioeconomic Data and Applications Center website, which had boundaries of all Kaveri delta villages. Her idea was to attribute a 'virtual' well to the centre point of all village surface areas in order to create a more uniform groundwater abstraction and smaller cones of depression. Second, the team set up a citizen-science program – but when Sneha was developing her model this program was still in its early stages.[17] Third, one of the team members and a co-author of this paper used Google Earth to manually identify borewells by zooming in and scanning for the very small sheds which accompany borewells and which house the electrical panel and power switch. This was arduous work, which was abandoned after he found and plotted over 3000 wells in the Peravurani area alone.[18]

What these attempts show – regardless of their success – is a kind of devotion or desire to improve upon this model and on the situation of the people whose lives are affected by reduced water flows in the delta. Although these attempts are not part of the latest model, the latter two hint at the potential for a more inclusive science, wherein scientists and end-users jointly tackle data-scarce situations and make that information available; this is something our team as a whole subscribes to (see Srinivasan, 2017; Agrawal et al., 2022). It resonates with one of the mantras of Sneha's ITT Bombay professor, her guru: science endeavours should not begin at its cutting edge, but with those people who most need it; not at some prestige university overseas, but in the field with local students, teachers, and people.[19]

Indeed, the people in the field – the Kaveri Delta farmers and their stories about the drying delta that inspired our work – provided us with insights to interpret the model (see also Prayag et al., 2023). In the model results, deeper aquifers showed a decrease in groundwater in particular zones, yet there was no observable trend of water levels dropping in the more accessible shallow aquifer. This apparent contradiction to farmer claims was explained to us when they indicated that their (shallow) wells (up to 45 metres) were no longer in use because a) of high salinity near the coast and b) at crucial times during their agricultural calendar, the wells ran dry. With this feedback, the model tells us about the large seasonal variation of the unconfined aquifer, which is becoming more saline with farmers drilling deeper into the confined, water-bearing layers.[20]

THE ART OF PREDICTING: BY DOWSING

It was February 2021. In a small house somewhere in Amsterdam, our anthropologist, Julien, was feeling happy and excited. He had just finished a WhatsApp. call wherein he and his Tamil-speaking team member had interviewed one of Dharmapuri's most renowned diviners, who worked as a local farmer and helped countless others find groundwater. They had contacted him out of curiosity after a team discussion about Krishnan's practices and vernacular ways of groundwater detection. In this case, the diviner, named Govindhan, found underground water flows within a large area because he had "a magnet in his body". In dowsing work, so suggested Govindhan, the greater this magnetic force, the more accurate the prediction would be.

A doctor, after performing a blood test on him some 20 years before, had told Govindhan about having a magnet in his body. It was a coincidence that he found out, as he was actually taking his uncle to see the doctor. For Govindhan, now 42 years old, this was a very important moment. He knew what this

[17] See http://cseincauverydelta.org.in/ (accessed 25-11-2022).

[18] Peravurani is subdistrict or *taluk* that covers almost 1900 hectares, making well density in this area 14 times higher than our estimated Tamil Nadu average in footnote 8.

[19] See https://www.ted.com/talks/prof_milind_sohoni_vernacular_science_the_science_of_delivery (accessed 25-11-2022).

[20] It also lays bare the complexity of groundwater dynamics and the politics of water table knowledge, as farmers are being convinced to invest in local groundwater recharge measures which are not connected to their wells. This is an observation also made by Aubriot and Prabhakar (2011) for two other districts in Tamil Nadu.

meant in terms of water divining, and reasoned, "People are suffering from lack of water day by day, and this is a profession for us [people in Tamil Nadu], too. So, I thought it would be useful for our future if I learned this". Govindhan hoped to both improve the situation of Tamil famers and develop his skills to pursue his goals in life.

Roughly four years after that doctor's visit, he helped a panchayat (local government) administration find the location in which to drill a borewell for drinking water purposes. It was his first prediction that resulted in a borewell and "after that, I predicted the point on my own land. And then I predicted for the panchayat wells again. Then I predicted for other farmers". Though he was now a diviner, his journey had started much earlier.

Talent and training

At age 16 or thereabouts, Govindhan started to experience odd things happening to him. "Sometimes a water can will fall down automatically when I carry it on my shoulder while holding it with my hand". He also sometimes felt a strange force or energy-like sensation when using "garden tools, like an iron crowbar and a spade". He emphasizes that during his childhood, he "did not have the energy or power to feel this", but he slowly became aware of (how to use) this force in his body as well as of the talent that he had – a talent many others don't have.

Following the blood test, Govindhan consulted with and learned from elderly persons who had knowledge of divining. He was never apprenticed to any guru,[21] but instead mentioned that in great part he is self-taught. He started by identifying a few wells already drilled – some of which were dry – and 'tried out' his magnetic force on his tools. It was a sensory practice his body needed to learn. "When I tested a few wells, I found that it works in wells where there is water but does not work in wells where there is no water". Next, he tested ways of gauging different depths. "In one well, the fountain is available above, in the other in five hundred feet, and in a few wells a thousand feet". All the while, he tuned into what his body was feeling. "Initially, I was not able to figure this out one hundred percent. It is not easy for anyone to know one hundred percent from the beginning".

It took him years of training to hone his skills, going out 2-3 times a week for several hours to practice. In a way, Govindhan was calibrating his body: trying, adjusting, checking, and trying again. "I had been doing this from nine o'clock at night to three o'clock in the morning for four or five years until I learned this profession" – first by checking known wells, later moving to open fields. He then started to converse with other diviners on how deep they consider the flow to be if the (neem) stick rotates once, twice, or multiple times, or whether how they felt the weight of the coconut (as a sensation of it being pulled to the ground) could indicate depth. After all that arduous work, he emerged as an expert in groundwater prediction.

Tools and trials

Not only can Govindhan predict the location and depth of water flows hundreds of feet down (up to an accuracy of plus or minus 50 feet), but he also can say something about the volume. He mentioned that he "can predict water flows up to [that is, as small as] one and a half inches or two inches".[22] But then *how* does he do it? The second author twice accompanied Govindhan to the field to observe[23] – and to

[21] Unlike Govindhan, Krishnan, the diviner we spoke with in Peravurani, did learn from a guru how to interpret the panchagam and predict groundwater flows. It took him 10 years, he explained.

[22] We understand here that Govindhan can find water flowing hundreds of feet down, in the fissures of hard rock that are 1.5-2 inches or bigger. He won't find water flows in fissures or sheets smaller than that size. It is incredible, at least to us, to imagine what this means when drilling a well 200 meters into the ground; for an impression see: https://www.youtube.com/watch?v=6lVTPhsvp38 (accessed 25-11-2022).

[23] These two moments of participant observation (on 20 February 2021 and 19 February 2022) were video-recorded and analyzed with the team.

try it out himself, to see if he had the talent as well. (He did not.) The first time was a demonstration, while the second was an actual water prediction for a client. For the demonstration, they met near Govindhan's village, from where they planned to go to a place where they would not be interrupted and the diviner could show his craft. Each of them brought a friend, and Govindhan carried a jug of water taken from home and a large knife they would use to cut the neem stick (to be found en route). On the way, they stopped randomly at a shop to buy a coconut. These, together with a set of keys attached to a magnet, were the tools of this dowser.

On the second occasion, Govindhan began by standing at the edge of his client's field and removing his shoes. He walked to the northeast corner with a small group that included the owner, the second author, and a few others. Here they found a termite mound, which is good indication of possible groundwater. At that mound, Govindhan performed a *pooja*, a ritual offering of flowers to an in-situ-made clay idol. It was meant to appease spiritual beings and forces that roam in or reside over the area.[24] The pooja took ten minutes. After that, Govindhan started walking away from the mound with the coconut in his hand. (Finding and tracing groundwater flows involves walking slowly through the fields with the coconut on the palm of your hand.) The coconut, Govindhan says, "will spin in the direction of the flow of water. It rotates automatically". He moved to the border of his client's field and then followed it. When he detected groundwater flows, he retraced his steps a couple of times to make sure and marked these places by scraping his foot on the earth repeatedly. Sometimes, when it appeared the earth was too hard or rocky to mark with his foot, Govindhan left a twig or branch. After he circled the entire field (two hectares of shrubland), he went back to the points he had earlier detected and used different tools for confirmation of the flow direction, then moved away from the border into the field.

Confirmation, Govindhan explained, is needed to improve accuracy. "The keychain rotates where the water is flowing and shows the direction of water flow", as will the neem stick. Instead of laying it on the palm of his hand, like a coconut, or hanging it from his hand like the keychain, he held the neem stick firmly in both hands. Earlier, during the demonstration he performed for us, Govindhan had explained that he can actually "use any stick we want, and all sticks will rotate. But the ritual is to use a v-shaped neem stick". It is not his preferred tool, though, as the stick generates a painful force. He relies mostly on the keys and coconut and can predict water flows down to two inches, up to depths of 1100 feet, or 300-350 metres.

To find water for his client, Govindhan spent more than one hour walking across the field, repeating certain stretches for dozens of times. He was looking for points where different waterflows crossed. In this field he detected two such potential points and circled them several times, making his assessment. Once he was sure, he informed the owner of the location where he should drill a well, the depth, and the yield (in inches); in this case, the best spot had five flows crossing each other, and Govindhan mentioned that water would be available at 150 feet, yielding 1.5-2 inches, and that the owner needed to drill to a depth of 700 feet.[25] His fee was 1000-1500 rupees, but beyond that he was happy he could help this

[24] Snakes are considered god-like and often live inside termite mounds. This was the reason to have the pooja here – not its indication of possible water. More than that, Govindhan considered starting in the northeast corner crucial. This direction is important in Tamil agricultural life: when transplanting paddies, farmers tend to start in that corner; temples often have a water body to the northeast; and the monsoon carrying water from October to December comes from the northeast.

[25] The second point he identified had two crossing waterflows, water was available at 200 feet, yielding 2 inches, and he advised drilling to 450 feet. The difference in borehole depth, or so we were told, is that in the more favorable spot water would flow longer and more continuously – the shaft acts here as a (small) reservoir. The second point, as we understood, needed less drilling but had a greater risk of running dry; the former would be more productive. Indeed, finding groundwater is one thing; knowing its behaviour over time is another. Challenging both logics, it can be affected by many geological and human interferences. Not all wells are or remain productive enough for farmers, meaning they are forced to drill several wells and deal with the costs and distress (Coste and Ploumpidis, 2007; Shah, 2012).

farmer find water. It is common that he receives additional gifts or money from farmers after they drill their well, based on the farmer's discretion.[26]

Dharmapuri water problems have made Govindhan anxious for several years now. Professionally, he cannot live from water prediction alone. He is also a farmer and works as day-labourer, so he has experienced some of the same struggles as many of his clients. Since he started divining, he has noticed that rainfall has decreased and most of the open wells in the area have dried up. Groundwater is only found at lower depths and with lower yields. This means that people have stopped cultivating paddies, only planted rainfed crops, or left their land altogether. By finding water underneath the earth, Govindhan feels he is helping to improve the livelihoods of his fellow Tamil people,[27] but only if they can afford the costs of drilling and have a proper electric connection to pump the water up from underground.

Thoughtfulness

The problem of lower groundwater levels is a growing concern in Dharmapuri. Govindhan can find groundwater down to depths of 1100 feet, but beyond that he cannot detect it accurately. We asked him if he could somehow extend it by creatively using other tools or knowledges such as in-situ environmental knowledge or the almanac. Govindhan stated, however, that he does not "find water flows with things like the almanac. Only those who have a magnet in their body can do this; others cannot do this". In the Kaveri delta, many diviners, like Krishnan, do utilize the panchangam when predicting groundwater flows.[28] It is a complicated process, the details of which are beyond the scope of this paper and, for the moment, our comprehension. But it has shown us much diversity in the ways that a water diviner or *neerottam pakkaravar* predicts the flow.

Our (basic) understanding of the panchangam comes from conversations that two Tamil-speaking team members, living in the Kaveri Delta, had with a third diviner. Here is what we understood: the panchangam is a calendar that connects celestial phenomena (the position of the stars, a waxing or waning moon, etc) to earthly activities (marriage, transplanting a paddy, maintaining water infrastructure, or finding groundwater). Consulting it tells you *when* the right or auspicious time is to do these things. Many farmers we spoke with indicate they won't harvest or sow before checking what is the best moment (in the day) to do so. One farmer mentioned that he plants rice or flowers during days when the moon is waxing and tubers, onions, and carrots when the moon is waning. There are other activities you should not do on certain days or in certain months. Thus, depending on the day, a diviner like Krishnan would not even start predicting the flow. But on the days that he can, again to our understanding, the panchangam can also indicate *where* the right or auspicious place to do so is located. A device is used which divides a field into twelve parts. A given star and zodiac sign, connected to a day that is particularly auspicious for finding ground, and the position of the moon on that day, lead the diviner to certain parts of a field and not others. On that day, and only in those parts, will a diviner finish his prediction.

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[26] Krishnan too asked 2000 rupees or less, which corresponds, for farmers who can pay for a borewell, to about two days of income.

[27] Govindhan mostly stays in his district or in the adjacent areas within a 30-kilometer radius. He does, however, frequently travel to other parts of Tamil Nadu. He expresses that he could detect water anywhere in India but does not see himself traveling to other states.

[28] The different methods of diviners – and Krishnan's focus on when to predict and construct versus Govindhan's emphasis on where – could be connected to the different ways that water flows (and can be found) underground: through aquifers or in fissures and cracks. Geology is obviously a crucial actor, just as in modelling: irregular inflow between years and spatial heterogeneity of cracks are added input challenges for modelling in hard rock, as is determining the aggregate volume taken up by all fissures and cracks in particular rock formations (Ahmed et al., 2007; Hora et al., 2019), which our Kaveri Delta model did not have to deal with.

In the paragraph above, we have incompletely described how a panchangam might be used. We are aware of this but wanted to demonstrate a radically different organizing principle from that of techno-scientific reasoning that informs groundwater prediction and is called upon by millions. In practice, we believe, every diviner finds flows in their own way, using their own tools. Krishnan, who trained and studied for 10 years to become a diviner, uses both the panchangam and a lemon. He favours the latter and also observes the surroundings for clusters of particular plants or termite mounds. "Good water is available there". But, "Only when I predict with a lemon will the deity I worship show me the location of the flow". During his training, his guru asked him to name one of his favourite deities and "I mentioned the goddess of Sri Ambal. Then he said you can predict the water flow using [a] lemon".

DISCUSSION AND CONCLUSION: COMPARING AND CONTRASTING GROUNDWATER PREDICTIONS

In this paper we described modelling and divining practices as two ways to predict groundwater flows. It is by no means our intention to give complete accounts of what it means to practise either, nor to engage in the controversy between these two groundwater logics, nor to pass judgement about which one is best. Instead, we began with the observation that these logics are entangled: the borewells drilled following a diviner's prediction (might) serve to improve the prediction of the modeller. We then set out to show that there are a lot of similarities to how each of them enacts groundwater – similarities that we mobilized as a device to treat both logics symmetrically[29] and take them equally seriously.[30] Hence, our 'care-ful' comparison uses a set of terms, starting with talent and training, followed by tools and trials, and ending with thoughtfulness, to describe each groundwater-predicting logic in the same way.[31] For our final reflection, we return to this schema but inverse it: we begin with thoughtfulness. Here we understand 'being thoughtful' as being both caring and reflective.

Thoughtfulness

When Govindhan and Sneha decided to, respectively, become a dowser and a modeller, they did so partly because of personal career plans and life goals. They were also driven by the situations of water stress they observed, which they wanted to improve. Both of them wanted to develop and mobilize their expertise to help solve the water problems of local people in rural India, particularly in the Kaveri Basin and near Mumbai. Without being overly emotionally engaged, both Govindhan and Sneha displayed a kind of practical care, consisting of efforts to be "contributing to restoring, sustaining, or improving something" (Mol and Hardon, 2021: 185). In both cases this was embodied in a kind of meticulousness[32] – that of painstakingly tracing one's steps (literally for Govindhan while walking the field; figuratively for Sneha when calibrating her model) to optimize one's prediction.

In the modelling case, we identify another kind, or version, of care: that of tinkering,[33] of sensibly and creatively 'making do' with the materials, equipment, and data at one's disposal or in one's surroundings.

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[29] See Hasan et al. (2021), who plead for and emphasize the importance of engaging symmetrically with delta knowledges and knowers in Vietnam, Bangladesh, and the Netherlands.

[30] Similar points have been made by Domínguez-Guzmán et al. (2017) and Verzijl et al. (2019); for an English version of the latter, see also Verzijl (2020, chapter 5). The kind of argumentation about and conversation between different water logics or realities in these works does not only show what both can learn from each other but also helps foster the idea of multiplicity, and creates space for diversity, in the water sector (see also Zwarteveen et al. 2021).

[31] Another example of predicting or 'anticipating nature' is given by Kirsten Hastrup (2012). She breaks down the process of modelling into several components to show that climate scientists and, for example, Nordic hunters both engage in practices of anticipation in similar ways.

[32] Elsewhere (Domínguez-Guzmán et al., 2022) we have discussed different versions of care, such the watchful care of Andean *cuidadores,* patrolling an old canal, or the adaptive care of a water manager operating in situations with a lack of information. Meticulous care is a version we add here where commitment and reiteration go together in reaching a particular goal.

[33] For other cases of (socio-technical) tinkering in irrigation, see Kemerink-Seyoum et al. (2019).

This is how Sneha tried to compensate for the lack of quantitative information. She played with different types of data, such as the available LU/LC maps, NASA shape files, and the manual plotting of wells in Google Earth, to get her model to run more smoothly. Tinkering as a way of engaging with the world or one's environment seems to be at odds with the more abstracted and instrumental way that designing models is often depicted. In water governance writing, tinkering appears to be more attributed to in-situ users or practitioners (cf. Benouniche et al., 2014; Verzijl and Dominguez, 2015; Chittata et al., 2021). When Govindhan goes to work, however – grabbing a water jug from the kitchen, cutting a random neem stick along the way and buying a coconut from a grocer en route – he is not tinkering or making do with that what is at his disposal. Although another tree branch or a different liquid-holding container might (and probably would) have worked for him, for our analysis, tinkering is not what is at stake here. More than that – or so we hold – we are looking at different methods of data collection. Govindhan wants to triangulate his findings and appears, in that sense, methodical. The contrast is subtle: where Sneha is creating patches for her tools (e.g. MODFLOW code) to predict more accurately, Govindhan seems to be gathering different tools to do the same.[34]

Tools and trials

We have shown how modellers and dowsers relate to groundwater flows; it is even possible to connect a single well to the predictions of both. In our case, the citizen science program has collected information on almost 800 wells so far. That data is currently being tabulated and will become input for the next version of our model, but the locations (and possibly the depths) reported by farmers have been predicted by diviners using a coconut or panchangam. These are interesting entanglements to think about, yet it is also clear that these logics are far apart: two different ways of knowing groundwater.

Actor-network theory scholars have shown repeatedly how specific, heterogeneous networks of humans, nonhuman actors, and methods – or trained experts, tools, and trials – may enact the same object or phenomenon, like wells or groundwater flows, in different ways (Callon, 1986; Law, 2004). In this paper we presented two groundwater-flow-enacting networks. The first connects laptops, codes, calibration, geo-hydrological education, mathematical modelling, scientists, maps, and databases to (ground)water abstractions and observation wells. The second ties together neem sticks, poojas, tracing footsteps, self-taught sensitivity, magnetic sensing, diviners, overgrown fields, and almanacs to groundwater flows and wells. Knowledge produced within one network cannot be properly explained by the methods, devices, and rationalities of the other. Both ways of knowing are thus local. Even if the algorithms constituting MODFLOW travel, the Kaveri model does not. For MODFLOW to be used elsewhere, the painstaking gathering of data, calibration, meticulous care, and tinkering – that is, the practice of modelling – will be required. Similarly, while Govindhan says he could find water across India if he wanted to, he also requires calibration when he goes to another setting.

Talent and training

Govindhan, as well as the farmers we interviewed, mentioned that not everybody can be a diviner. You need to have a magnet in your body, Govindhan would say, and some farmers acknowledge this or some other force they themselves do not have. In 1959, Ramasubbu, in his book, *The Miraculous Water Flow into the Earth*, wrote about dowsers being among "a very small number of people who are naturally endowed with special electrical energy and electrical motion in the body", and that "no matter how many

[34] For comparable versions of care, he would need to be woodworking a board into a stick or in-situ adding sand to the water jug to change the make-up of the fluid, while Sneha would be seeking confirmation of her predictions by looking for new tools, codes or applications to compare to her model.

Shastras [procedures or written texts] are learned (…) the power to know springs and flows within the earth" is not possible without having this energy.[35]

Sneha, on the other hand, has a knack for math. Although today many math professionals believe that mathematical ability is not genetic and that being good at math is a matter of practice (itself a controversy that is still not fully settled), it is hard to not think of some of history's miraculous mathematicians as being somehow naturally endowed.[36] The point we want to emphasise, however, is that regardless of whether it is a matter of talent or a matter of training, it is incontrovertible that most societies have invested countlessly more in developing people's mathematical abilities than in their magnetic sensitivity.

The latter is often dismissed, ignored, ridiculed, or even criminalized in the water sector (and beyond).[37] What it would mean if these kinds of sensitivities were accepted and even embraced instead is mostly speculation, though from the medical community we learn that energy healers, like reiki practitioners and magnetizers, are becoming more and more recognized.[38] In certain countries these treatments are covered by health insurance companies, which in turn strengthens inclusion, quality guidelines, training requirements, expert associations, and so on.

Govindhan is not part of a diviner association, nor has he ever heard of one, while Sneha is member of the Indian Society of Hydraulics. He is also not aware of any kind of government program in support of divining, like there are for other types of extension services such as crop management, land preparation, or rainwater harvesting. We have heard of occasional diviner gatherings and government branches hiring them to find water, which has happened to Govindhan. But these occasions are rare, and scepticism is common.

From groundwater knowledge to practices of knowing

To counter that doubt and ambivalence, we have shown that divining and designing are less far apart than many would think. For both modelling and dowsing, special skills are required that are learned over a long time, and in both cases, commitment and reiteration are celebrated. Acknowledging these similarities can help treat dowsing more seriously as a different way of knowing – one that has its own logic and place in water governance. After all, millions of Tamil Nadu water users rely on it, and not only for the instrumental finding of water, but also to ask for good fortune by offering a pooja or to find out the auspicious times for certain water-related activities.[39] With this paper, we hope to have reduced some of the scepticism that accompanies dowsing. By focusing on how scientific and other knowledges are done in practice, dowsing also appears as a logical knowledge that is alive and influential. Following the call of care scholars (de la Bellacasa, 2011; Mol, 2008), our symmetrical analysis has allowed us to show that both ways of knowing belong to, are established, and are celebrated in specific networks – in

[35] The book is written in Tamil and translated by one of the authors. We also interviewed dowsers in Peru, in January 2022, who expressed that they had a rare God-given gift to find underground flows.

[36] Beyond the scope of this paper is the life history of Srinivasa Ramanunjan, one of the renowned mathematicians of the previous century, from a Tamil family and largely self-taught. He later found a mentor at Cambridge University, who, "on the basis of pure talent on a scale from 0-100" gave himself a 25 and Ramanunjan a 100, connecting the latter's genius to "some kind of deep 'intuition'". Ramanunjan himself understood [math] as spirituality. (Quotes are from a web-based article by Georgi Johnson (2016); see https://perception.inner-growth.org/the-science-spirituality-of-srinivasa-ramanujan/ (accessed 25-11-2022)).

[37] A misunderstanding of (or not being able to grasp different) incommensurable logics is probably a factor. The team members showed a lot of patience and went to great lengths to explain these to each other. For the team's Dutch anthropologist, understanding how modelling works was hard; the panchangam, clear to the Tamil co-researchers, seemed still more complicated; and knowing what it feels to dowse will likely be forever beyond his research. Yet only mutual respect and joint learning amongst these different knowers and knowledges makes fruitful collaboration possible – or so we hold.

[38] For example, Jane Hart (2012) describes how in the past energy therapists working as nurses in a hospital gave treatment 'in secret' – that is, invisible to hospital administration – while now they add the alternative treatment to the patient's file.

[39] That these kinds of customary and ritual practices matter in local water relations has long been established. See, for example, the work of David Mosse (e.g. Mosse, 2003).

logics from which they cannot be disentangled. Acknowledging this, we hope, contributes to the diversification and multiplication of ways of understanding groundwater that is needed for transformations to sustainability (Zwarteveen et al., 2021).

Perhaps these logics can accompany each other to address sustainability and justice concerns in groundwater governance. Sneha, as a scientist, would have benefited a great deal if Krishnan or Delta diviners would have somehow documented their predictions. Of course, the location they predicted is recorded in a way, but it would have been tremendously helpful if she had also been given the date and depth to tabulate. "That would be my happiest day ever", she responded when presented with the suggestion. Actively searching for and pairing different ways of knowing may also offer an opening to more transdisciplinary ways of doing science, closer to the people who most need it: a 'vernacular science', as her ITTB professor would call it. This requires creating spaces where different ways of knowing can meet and cultivating an attitude of thoughtful attention towards the other – even when he or she uses terms or logics that appear strange or non-conventional. This is what we are doing as a team and in our weekly meetings, and we hope this paper is a contribution to more collaborative and 'care-ful' modes of doing science.

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