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Differentiated Access: Challenges of Equitable and Sustainable Groundwater Exploitation in Tanzania

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ABSTRACT: Groundwater is an important resource for a large share of the global population and economies. Although groundwater dependence in most sub-Saharan African countries is relatively low at the national level, localized overexploitation is occurring, leading to a decline in groundwater levels and quality deterioration. Currently, the sustainable and equitable governance of groundwater, both through promotion and regulation, is turning out to be a key challenge in many sub-Saharan African countries. This paper uses case studies of urban groundwater governance in Arusha, and rural groundwater development in the Pangani basin, to analyse how the current policy and regulation inadvertently creates spaces for asymmetric access to (good quality) groundwater resources in Tanzania. It shows how the groundwater landscape is evolving into a situation where small users (farmers and households) rely on springs and shallow wells, while large users (commercial users and urban water authorities) are encouraged to sink deep boreholes. Amidst a lack of knowledge and enforcing capacity, exacerbated by different priorities among government actors, the water access rights of shallow well and spring users are being threatened by increased groundwater exploitation. Hence, the current groundwater policy and institutional setup do not only empower larger actors to gain disproportionate access to the groundwater resources, but presents this as a benefit for small users whose water security will supposedly increase.

KEYWORDS: Groundwater governance, access, equity, sub-Saharan Africa, Tanzania

INTRODUCTION

Groundwater storage in Africa is estimated to be 0.66 million km^3, more than a hundred times the estimates of the continent's annual renewable freshwater resources in the form of river discharge and groundwater recharge (MacDonald et al., 2012). Not all of this stored groundwater is evenly distributed or (easily) accessible for abstraction (in terms of both its quality and quantity), and some of it is not renewable. However, it is still seen as having enormous potential for achieving water security for millions of people (AMCOW 2008). Especially the threat of changing precipitation patterns arising from climate change makes the slow response of groundwater to meteorological conditions attractive, thus functioning as a natural buffer against climate variability (MacDonald et al., 2012). Partly because of this, groundwater resources are increasingly seen as a potential source of irrigation and domestic water in rural and urban areas. Current estimates indicate that groundwater use in Africa is still limited, yet increasing due to the over-allocation of surface water, population growth, and technology transfer (including solar energy development and the availability of cheap petrol pumps). These recent developments have resulted in localized overexploitation of groundwater resources, especially in urban areas, leading to a decline in groundwater levels and quality deterioration (see also Walraevens et al., 2014; Nlend et al., 2018). As such, the sustainable and equitable governance of groundwater, both

through promotion and regulation, is turning out to be a key challenge in many sub-Saharan African countries (Braune and Xu, 2008; Pavelic et al., 2012).

Groundwater is often called a horizontal resource, meaning anyone located above an aquifer is capable of independently sinking a well to extract water from it (Hoogesteger and Wester, 2015). However, this framing presents a neutral process of groundwater access and ignores how this access can be differentiated among different actors. In practice, capability to access groundwater is determined not only by one's physical location, but also by the social relations (material, cultural, political-economic, including access to financial capital and technology) that may be constraining or enabling access to groundwater. We know from elsewhere that increased abstraction of groundwater can lead to overexploitation and a 'race to the bottom', in which the poor generally lose out (Shah, 2009). While the body of literature on surface water management and its losers and winners in Africa is ever growing (see also van Koppen et al., 2016), very little research has been done on the governance of, and access to groundwater on the continent. Contrary to for instance India, where scholars have repeatedly looked at groundwater governance and issues of equity and access (e.g. Shah, 1989; Moench, 1992; Pant, 2005; Srinivasan and Kulkarni, 2014), past studies concerning groundwater in sub-Saharan Africa have ignored equity questions and have primarily focused on assessing groundwater availability for different types of development (Pavelic et al., 2012; Pavelic et al., 2013b; Bonsor et al., 2018), estimating and describing overall groundwater use (Pavelic et al., 2012; Siebert et al., 2010), analysing under what conditions groundwater use (for irrigation) is likely to occur (Chokkakula and Giordano, 2013; Pavelic et al., 2013a; Villholth et al., 2013), and arguing the role governments should play in further developing and managing groundwater (Braune and Xu, 2008; Foster et al., 2012). We start to remedy this gap in the literature by looking at Tanzania's past and current groundwater policies and laws, their implementation, and how the implementation of the current policy shapes inequitable access to groundwater in uneven waterscapes. We draw on the theory of access developed by Ribot and Peluso (2003) to develop a framework to analyse the processes of groundwater access in Tanzania. We then show how the current groundwater policy and institutional setup in Tanzania contribute to the empowerment of large users, while convincing smaller users that this is for their own good.

CONCEPTUAL REVIEW: GROUNDWATER ACCESS AND REGULATION

The challenge of groundwater governance has often been translated into a management system where the state issues water permits in an attempt to keep the annual water abstractions at a rate equal to, or less than, a given aquifer safe yield (Mukherji and Shah, 2005). This form of water control however, has proven to be challenging due to the large amount of resources needed to police dispersed groundwater users (e.g. Mukherji and Shah, 2005; Qureshi et al., 2010). In most countries, government attempts to regulate groundwater have not produced a significant reduction in the level of overexploitation (Hoogesteger and Wester, 2015), as a large part of groundwater abstraction does not occur within the state's legal framework. Other governance models such as self-regulation implemented to manage groundwater overdraft (see Wester et al., 2011 for Mexico and Kulkarni et al., 2015 for India) have not been successful either. To regulate groundwater use effectively, there is a need to understand the actual dynamics of both formal and informal groundwater access mechanisms.

Ribot and Peluso (2003) define access as 'the ability to derive benefits from things – including material objects, persons, institutions and symbols' (p. 153). 'Ability' in this definition means the capacity of an actor to influence other actors' actions, and the effects of the relationships that emerge from such social actions (Ribot and Peluso, 2003). The authors conceptualise social actions as the ability to mediate other actors' access (*access control*), and to spend resources or power to keep open a particular form of access to a resource (*access maintenance*). Access is thus the means through which different actors are able to benefit from things. Ribot and Peluso (2003) identify the means as consisting of two interdependent access mechanisms: right based (laws, customs and conventions) and

illicit access on the one hand, and structural and relational means of access on the other. Right-based access includes actions sanctioned by law, customs and convention, while illicit access includes theft and the use of force. Structural and relational access mechanisms are considered to operate parallel to right-based access but reinforce one another. They include a wide range of factors e.g. technology, capital, market, labour, knowledge, authority, identity, and social relations. According to Ribot and Peluso (2003) right-holders do enjoy a certain degree of social power and authority that may be granted by laws and customs. In addition, "discourse and ability to shape discursive terms deeply influence entire frameworks of resource access" (Ribot and Peluso, 2003, p.169), and are therefore crucial to studying access.

Hoogesteger and Wester (2015) build on this understanding of access and propose the use of a three-layered conceptual framework to study legal and illegal groundwater access. Their first layer looks at how the configuration of technologies, humans, groundwater and other productive and material resources shape access. The second layer looks at how the interaction between the political economy of groundwater dependent commodity chains and related policies contributes to the prevailing water use situation. Two specific areas are identified for analysis in the second layer: 1) how commodity chains and associated profit margins determine who gets to extract groundwater where and for what use; and 2) agrarian and water policies, laws and customs defining who can legally access groundwater, how and why. It is in this layer that the analysis of the impact of plural laws (formal and informal) on access comes in. The third layer considers the role discourses play in mediating groundwater access and accumulation (Hoogesteger and Wester, 2015).

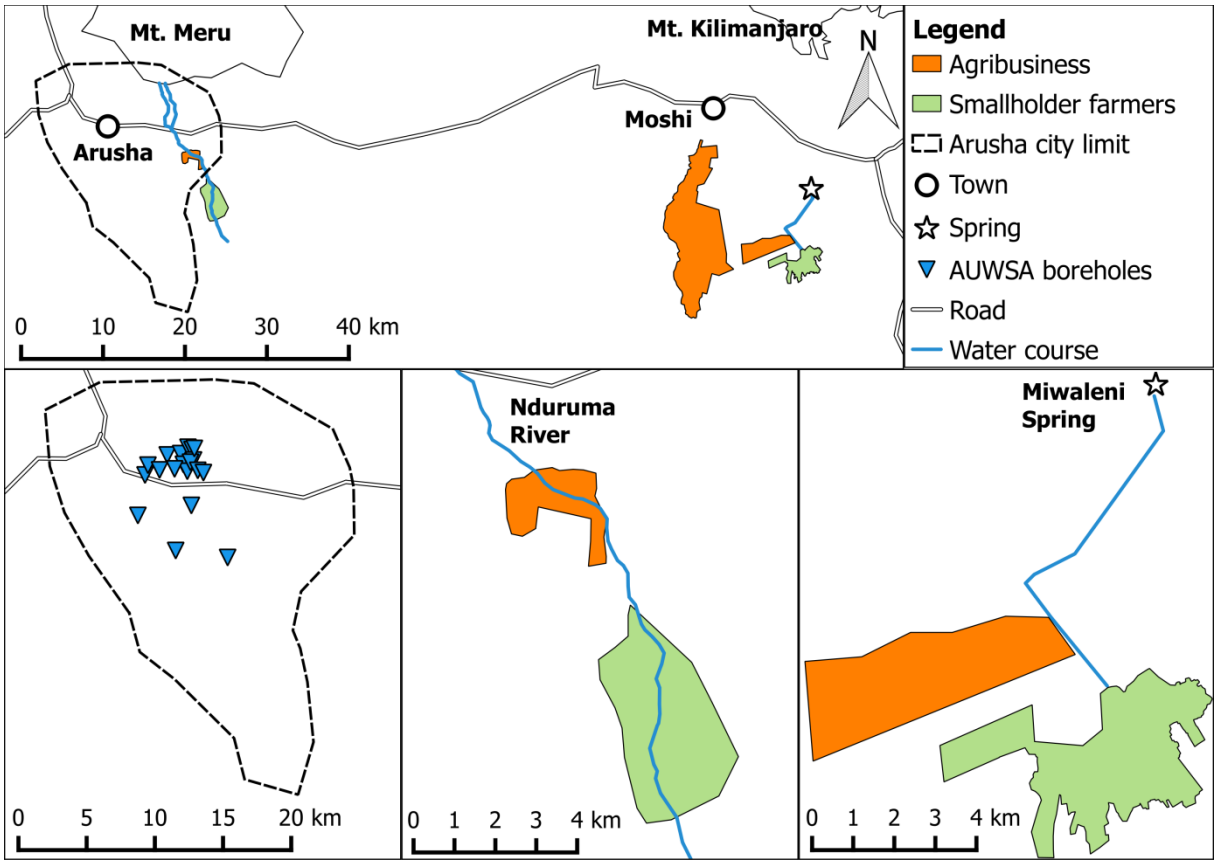
In our case study, we see that structural and relational mechanisms (e.g. knowledge, financial capital, technology, and authority) as identified by both Ribot and Hoogesteger are the key factors that shape the processes of gaining, maintaining, and controlling access to groundwater resources. At the very basic level, knowledge of groundwater availability, how and where to construct a well or borehole, determines who is able to invest to legally or illegally gain, control, or maintain access to the water resource. Next, access to technologies (pumps and power supplies) determines the extent and modes of extraction by which different actors can benefit from the resource. Knowledge and technology are interlinked and are in turn mediated by access to capital, policy and regulations (Aubriot et al., 2018). Actors' investment (in the form of labour, knowledge, technology, materials, and capital) establishes their access to groundwater and shapes power relations. This investment process is somewhat similar to what Coward termed hydraulic property creation (Coward, 1986). The property relation created is mediated further by the typologies of the dispersed technologies in use and the groundwater flow processes (Coward, 1986). The individualised hydraulic property may initially generate significant welfare and benefits to the investor, but over time such benefits will decline once overexploitation results into substantial groundwater level decline (Hoogesteger and Wester, 2015). Falling groundwater levels induce access inequity, as only those able to enlarge and deepen their wells will continue to exploit the resource (for a detailed discussion see Hoogesteger and Wester, 2015; Shah et al., 2003). Although the law provides framework regulation, it is not necessarily able to control the process of gaining groundwater access. However, laws may become important when there is overexploitation or extreme groundwater scarcity.

For this paper, we draw on the theory of access of Ribot and Peluso (2003) and the framework developed by Hoogesteger and Wester (2015) to analyse how the implementation of Tanzanian groundwater policy and regulations shapes access to groundwater and creates uneven waterscapes, and how this is mediated by the discourses dominant in different Tanzanian policy domains. In the following sections, we first analyse Tanzania's groundwater policy and regulations, followed by two cases of groundwater access differentiation between small- and large-scale users in the upper Pangani Basin.

METHODOLOGY

This paper builds on past and ongoing research work of the authors in the field of urban and rural groundwater use and management. The urban case draws on research conducted by the first author in the Arusha area from 2016 to 2018. The methods used include review of government reports, policy and regulation, semi-structure interviews, questionnaires, direct observations and secondary sources (e.g. thesis, meeting reports). The rural case descriptions stem from qualitative studies done by the second author in Arusha in 2012 (see also de Bont et al., 2016) and in the Lower Moshi area between 2016 and 2017. These studies included interviews with farmers, agribusiness owners, and officials from the Pangani Basin Water Board as well as the use of secondary sources (letters and water permit applications).

Figure 1. Overview of the studied urban and rural case studies of groundwater use in northern Tanzania.



TANZANIA'S GROUNDWATER POLICY AND REGULATIONS

While there have been areas in Tanzania where (seasonal) surface water scarcity led to conflicts and debates on conservation and redistribution since early colonial times, the nation-wide concerns about water stress really started in the early 2000s. Yang et al., (2003) predicted that Tanzania's renewable water resources would be less than 1500 m^3/capita/year, a threshold the authors claimed would have a seriously negative impact on food security in the country. In addition, a World Bank economic update report of 2017 stated that Tanzania's available renewable water resources declined from about 3000 m^3/capita/year in the 1990s to around 1600 m^3/capita/year in 2014 (World Bank, 2017). The sharp

decline in renewable freshwater per capita is attributed to the country's rapid economic and population growth leading to increased water withdrawal for agriculture and other productive activities.

Tanzania's water policies reflect the growing pressure on the country's water, with increasing attention going towards the conservation rather than the exploitation of water resources. However, neither the promotion nor the regulation of groundwater use has received much attention in Tanzania's laws and policies. The first water law developed by the Germans and later implemented by the British colonial government in 1923 focused primarily on surface water regulation. The colonial government's interest at that time was to limit surface water use by native farmers in favour of large commercial settlers (van Koppen et al., 2004). Drawing from the English Common Law, groundwater was considered the property of the one who developed it (Kanthack, 1936). During this period gaining groundwater access was only mediated by the technology and knowledge of its availability. The colonial authority only put limited resources and efforts in groundwater exploration activities[1] and almost ignored regulating groundwater use. Formal water law was mostly used to control native access to surface water. As such it was not applicable to everyone, only settlers could obtain permits (see also van Koppen et al., 2004). However, following subsequent amendments of the law in 1948 and 1959, all water resources in the territory, including groundwater, were vested in the state (for reviews see van Koppen et al., 2016; Komakech et al., 2011; van Koppen et al., 2014; van Koppen, 2007; van Koppen et al., 2004). After independence, the Tanzanian government largely adhered to these colonial water laws. In spite of some minor tweaking and the fact that the laws now apply to everybody, present water law contains a substantial amount of wordings that can be traced back to 1923.

The Water Utilization (Control and Regulation) Act of 1974, and its regulation of 1975, was the first law to be more explicit about state-led groundwater regulation (URT, 1974). The act provided the right to casual groundwater use to owners and occupiers of any land as long as the abstracted water from the sunk or enlarged well or borehole did not exceed 22.7 m^3 per day. Casual water use was considered non-commercial use of the water extracted. No formal water right was required, as long as the wells or boreholes were not within 230 meters of each other or within 90 meters of any surface water body. The subsequent amendments of the 1974 Water Utilization (Control and Regulation) Act in 1981, 1994, 1997, and 2002 mostly maintained the right to casual groundwater use.

Currently, Tanzania has nine river basins, each managed by a basin water board that is responsible for the management and development of water resources. At a more local level, catchment committees and water user associations are being developed, which operate under the supervision of the basin water board. These lower level institutions are largely geared towards surface water management, with the Water Resources Act stating that 'the association of water users (…) shall comprise of any user of water from a common *stream*" (URT, 2009 p.397, emphasis added). Groundwater management is the responsibility of the basin authority where the aquifer is found. Present groundwater management strategies are primarily guided by the Water Policy of 2002 (URT, 2002) and the 2009 Water Resources Management Act (URT, 2009). The 2009 Water Resources Management Act (URT, 2009) repealed the Water Utilisation (Control and Regulation) Act No. 42 of 1974. It modified access to casual groundwater to read "any person being the legal owner or occupier of any land may construct a shallow hand dug well and use the water for domestic purposes without Groundwater Permit issued (…)". The same law also dictates that anyone wanting to "construct, sink, enlarge, or deepen a well or borehole in a Groundwater Controlled Area or any other area" needs a groundwater permit (URT, 2009, p. 387). The water use permits are allocated by the responsible Basin Water Board, which is also supposed to define the sustainable borehole or well yield. The law defines safe (sustainable) yield as "the amount of water

[1] In 1946 for instance, the Department of Water Development reported the successful drilling of seven boreholes. In 1947, this was ten, and in 1948 twelve (Department of Water Development, 1946; Department of Water Development, 1947; Department of Water Development, 1948).

which may be abstracted from an aquifer at a rate that shall not reduce the supply to such an extent as may render such abstraction harmful to the aquifer, to the quality of water or the environment" (p.388). Anyone using water without a groundwater permit is liable to a fine not exceeding TZS 500,000 (about 221 USD) or imprisonment for a period not exceeding 6 months or both (URT, 2009). On paper, the present water law is the primary means of gaining and maintaining access to groundwater in Tanzania.

The requirements for groundwater exploration and development are defined in the 2013 Groundwater Licensing Regulations, which are part of the 2009 Water Resources Management Act. The regulations state that drilling companies have to be registered and must obtain a permit to conduct business in groundwater exploration and development (URT, 2013). Drilling licences are issued in two classes, determined by the depth a drilling company is able to reach. Class one is for companies able to drill to a depth of more than 100 meters, while class two is for those able to drill a borehole of up to 100 meters. There are no special regulations for the digging of shallow wells.

Although the Water Resources Management Act and the matching regulations do not specifically link certain types of water abstraction to certain classes of people, they do create a policy environment in which deep groundwater becomes less available to the poor. The Act clearly states that shallow wells (the depth of which is not further specified) can be used for domestic purposes without the need for a water use permit or a groundwater permit. All other groundwater abstractions, or the construction or enlargement of wells/boreholes do need such permits which come with further requirements. The construction or enlargement of a well or borehole is to be done by a licensed individual or company, and involves a formal process including an environmental impact assessment, a geological survey, test drilling and pump testing. These requirements raise the costs for the legal drilling of deep groundwater, making it practically inaccessible to those who do not have access to financial capital.

CASES

Urban groundwater use in Arusha

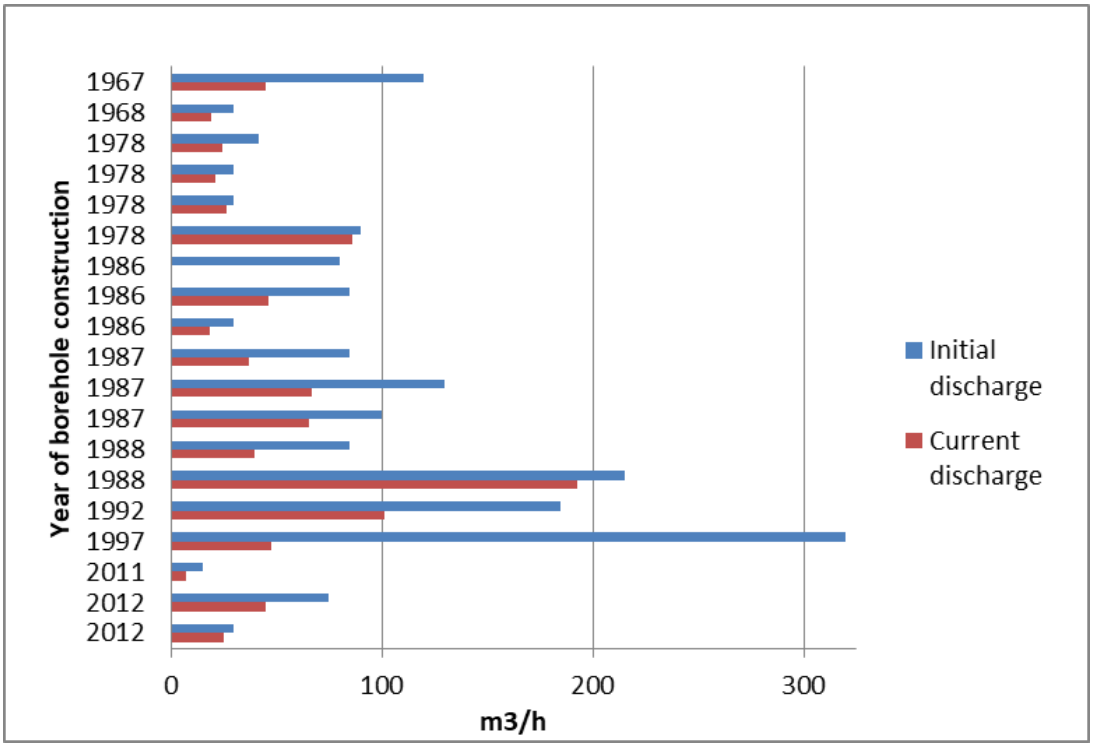
Arusha is a fast growing city of about half a million residents located at the foot of Mount Meru in Northern Tanzania. Tourism is one of its main economic activities, and due to a favourable climate there are also a large number of foreign horticultural agribusinesses located around the city. In addition, agriculture is practised by smallholder farmers both upstream and downstream of the city. The city also harbours several agro-industries. Arusha Urban Water Supply and Sanitation Authority (AUWSA) is the legal entity established to provide water supply and sewerage services in the City. The utility was established under the Tanzania Water Works Act CAP 272 amendment (Act No. 8 of 1997), which is now repealed by Water Supply and Sanitation Act No. 12 of 2009. AUWSA therefore sees itself as the sole authority responsible for supplying water to the city residents and by extension also responsible for conserving the water sources for sustainability.

Water scarcity is a major problem in the city, with only about 7.6% of the estimated population of 507,903 having access to the AUWSA piped water supply networks (AUWSA, 2014). Groundwater contributes about 33% to the city's formal water production, which is 35,000-45,000 m^3/day. Although AUWSA is investing to develop new sources, it is not able to cover the whole area. Poorer neighbourhoods often receive 2-3 days per week of AUWSA water supply (Aponte, 2016). In addition to the expanding urban areas and growing population, AUWSA faces high conveyance losses and water theft (about 50% of AUWSA's water supply in Arusha is unaccounted for, and this goes up to 80% in the Central Business District), which further exacerbates the water shortage. As a result, the utility water demand gap is about 5800 m^3/day. The hope is that the rehabilitation of the pipe network and the development of new water sources will solve the water shortage. In order to achieve this, the African

Development Bank approved a 211 million USD loan for the Arusha Sustainable Urban Water and Sanitation Delivery Project in 2015, which is to be completed in 2019 (AfDB, 2015).

Regardless of these major plans for improving service delivery, the majority of the poor population still relies on self-supply from private groundwater sources (primarily shallow dug wells, and some deeper boreholes) or water vendors. A questionnaire survey conducted in five wards of Arusha found that 28% (86/302) of the respondents have groundwater (springs, boreholes and shallow wells) as their main water source. In addition, 71% (172/242) of households relies on springs, boreholes and shallow wells as their secondary water source. Overall, households in Arusha use 28 different combinations of water sources, including shallow dug wells, boreholes, AUWSA piped water, and bottled drinking water among others (Abas, 2016). More than 50% of these combinations involve the use of groundwater sources (Abas, 2016). The groundwater self-supply sources however, can also be expected to be impacted by AUWSA's increased groundwater abstractions and the expansion of the city into groundwater recharge zones. Data collected by AUWSA shows that the yields of all their boreholes (varying in depth between 63 and 189 meters) have gone down since they were constructed (Figure 2), and a recent study on the impact of urbanisation and climate change on groundwater in Arusha estimates that there will be water level drawdown of up to 75 metres in some parts of the town by year 2050 (Olarinoye, 2017). During field interviews and meetings, community leaders (both from churches and mosques) have stated that it has become difficult to get groundwater at shallow depths in some parts of Arusha unless drilling to depths exceeding 150 m. One particular mosque leader in charge of a project of drilling 15 deep boreholes attributed this recent difficulty to the general decrease in groundwater availability in the city.

Figure 2. Changes in the discharge of AUWSA boreholes constructed between 1967 and 2012.



These dropping water levels are projected to cause many existing water sources of urban residents to dry up, without them having the financial capital or technical capacity to deepen their wells. In addition, the city's poor sanitation infrastructure is leading to pathogenic and nitrate pollution (up to 120 mg/l)

of shallow groundwater (Morienyane, 2016). Households dependent on shallow wells are therefore using faecal contaminated water. There are also high levels of fluoride concentration (reaching 50 mg/l) in Arusha's groundwater sources (Morienyane, 2016). Fluoride concentration was found to vary randomly, and is likely to arise from the dissolution of sodium-rich silicates present in the aquifer. Better quality groundwater with low nitrate and pathogenic pollution is much deeper at about 80-150 metres (Morienyane, 2016), making it out of reach for most households. Only industries and a few rich urban residents have been able to finance the formal process of acquiring groundwater permits to drill deep boreholes to augment their water supply from AUWSA network. Several churches and mosques are securing external funds to invest in deep groundwater development as part of their community development projects and maintaining followers.

Various private groundwater drilling companies operate in the city, some of which do not strictly follow the provision of their drilling permits. Most of the drilling takes place informally, during the weekend without the knowledge of the basin water board or AUWSA. Informal drilling of a deep borehole of 80-150 m costs about 2000 USD (because the one ordering the drilling avoids carrying out mandatory surveys and paying the necessary taxes). This is more than ten times the cost of a 15-30 m hand-dug shallow well, which is reported to cost about 200 USD. The cost of formal drilling, a process that includes permits, geological surveys, pump, drilling and pump testing, is in the range of 7000-25,000 USD, depending on the nature of the area, depth to be drilled, and the well diameter. This figure is well above the informal cost and out of reach of most households. Users following the formal process are generally large commercial users, such as industries or agribusinesses, which do not only have sufficient financial capital but are also already on the radar of the water authorities. In addition, these users often need deep and large boreholes to satisfy their water needs, which take longer to drill and are therefore less likely to escape the notice of authorities than smaller informal boreholes, often drilled over the weekend.

The responsibility for groundwater regulation is fragmented and the interests of different government actors are often contradictory. Despite the existing water shortage, the municipal city authority for instance, is looking at urban expansion as a way of modernising the city and creating new economic opportunities. They want to develop a system where land becomes an important asset in terms of revenue generation through land rents and title deed sales. The Pangani Basin Water Board (PBWB) on the other hand wants to control degradation of groundwater recharge areas, which would mean curbing further urbanisation. At a 2015 meeting, the Regional Commissioner reportedly tasked the Pangani Basin Water Board (PBWB) to pinpoint the exact places which should be gazetted for groundwater protection and included in the recently concluded 2035 City master plan (Pers. Communication). AUWSA, rather than protecting recharge areas, wants to regulate groundwater use in the city and reduce the number of private boreholes and shallow wells. The private water sources reduce AUWSA's revenue and it is impossible to distinguish between people legally pumping groundwater and people stealing water by pumping directly from the utility piped network. Due to low and intermittent supply, water pumping is a common practice in the city. In the process, some households bribe water technicians to bypass the AUWSA meter during initial construction, directing both the utility supply and well water to one storage tank. Others install a pump directly onto the AUWSA line connecting their house and operate it to increase water pressure. This makes it difficult for AUWSA to verify if a household is only using well water or not. To overcome this problem, AUWSA is removing water meters from within the housing compound and installing neighbourhood meters. By locking all neighbourhood meters in a manhole outside the housing compound it is hoped that water theft can be minimised.

Formally however, groundwater use is controlled through the issuing (or rejection) of permits, which is the role of PBWB. The PBWB thus tries to make all groundwater users visible to the state by mapping and issuing abstraction permits. The basin water board, through its sub-office in Arusha, has been drawing up inventories of wells and boreholes in the city. The permits are the main source of revenue

for the basin water office, which has rarely rejected groundwater permits as long as the applicant could pay for it. This of course rapidly contributes to skewing access to groundwater by law and not just 'discourse' about who gets to use it. The municipality is worried about shallow wells from a health point of view, and has been involved in the construction of deep boreholes in the past.

So far, the implementation of any kind of groundwater regulation has not only been hampered by disagreeing authorities, but also by a lack of knowledge on both the nature of existing aquifers, the locations of recharge zones, and actual groundwater abstractions. Creating groundwater control areas would be an easy first measure but this has not happened. Due to the fact that both human and financial resources are insufficient to facilitate the necessary studies, it is unlikely that this situation will change in the near future. Poor urban residents are still likely to lose out as their hand-dug wells dry up, while different authorities are trying to maximise their revenues but are unable to sustainably manage aquifer levels or groundwater quality. To some extent, increased groundwater abstraction and decreased recharge already seem to be impacting groundwater availability, as AUWSA borehole yields decrease and small users notice (localised) dropping of groundwater tables.

Irrigation groundwater use in Arusha (Nduruma) and Kilimanjaro (Kahe)

When it comes to rural groundwater in the Pangani river basin, the state's position towards groundwater exploitation and conservation has been ambivalent over time. In many places, groundwater is the only water source available for domestic use, and as such its exploitation for drinking water systems is promoted. However, when it comes to groundwater as an agricultural water source, the attitude of officials from the Pangani Basin Water Board oscillates between the fear of overexploitation and the desire to increase overall accessibility to water in an otherwise closing basin. With the reducing availability of surface water resources, groundwater is often seen as a means of avoiding conflict, especially between large-scale (foreign) commercial users and local smallholder communities. Large-scale agribusinesses are pushed towards using groundwater to alleviate pressure on surface water. As we show below, the general attitude of both smallholder farmers and government officials is that those with money should invest in groundwater development and leave surface water for the poor. Below we discuss two cases in which there is a call from government and communities for a commercial water user to switch to groundwater. We briefly outline the situation related to water availability and water use, the arguments used and the outcomes in terms of groundwater use. In the first case, the involved agribusinesses did indeed start exploiting groundwater, but in the other they did not, and we reflect on why this is.

The first case concerns horticultural agribusinesses close to Arusha city, and the downstream smallholder communities that use the same river (see also de Bont et al., 2016). The horticultural agribusinesses grow seeds or flowers in greenhouses, exclusively for export. Downstream smallholder communities primarily cultivate a combination of maize and beans. All use water from the Nduruma River, which sees its water levels dropping, especially in the dry season. The lack of water has led downstream communities to challenge the agribusinesses' water use, at times resulting in violent conflict. After negotiations, the agribusinesses reduced their water abstractions and started using groundwater instead. Currently, most of the water used by the agribusinesses comes from boreholes, with the river water running downstream to feed into smallholders' canals. The agribusinesses' investments were demanded by smallholders, who used arguments based on the foreign nature and the financial capital of the agribusinesses. As a group of smallholders summarised: "The investors should use groundwater, because they have money. They are lucky to be getting any river water". Another farmer added: "They think of their flowers, we think of drinking water. The government could tell them to dig for their own water". The Pangani Basin Water Board did in fact welcome the agribusinesses' shift to deep groundwater, as they saw it as the perfect way to reduce conflict in an area that had been demanding their regular attention. The agribusinesses complied with the communities' wishes to avoid conflict, but also because the higher level of water security and the

superior quality of the groundwater outweighed the cost of investment. Meanwhile, little is known about the interactions between surface water and groundwater, with some of the boreholes being located close to the river. The PBWB, in charge of issuing groundwater permits, requires a feasibility study for each new borehole, but this study assesses groundwater availability, not the impact it might have on the overall water balance. Financial constraints are given as the reason for the lack of further hydrogeological studies. One agribusiness owner expressed the view that it was not in their personal interest to conduct or facilitate further hydrological studies, as it could only negatively affect them. Smallholders in the area did not demand such a study either: not a single interviewee expressed concerns about groundwater abstraction influencing river water availability. Due to the annual and seasonal fluctuations in river discharge, it is difficult to say anything about the impact of the increased groundwater abstractions on the river flow without doing a proper hydrological study.

The second case is eighty kilometres east of the Nduruma River, where the Mauritian owned Tanganyikan Planting Company (TPC) cultivates around 9000 hectares of sugar cane. While the vast majority of the estate is irrigated with water from the Weruweru River, 1300 hectares use water from the Miwaleni Spring. This area is a relatively new addition to TPC, which took over the land from a failed estate in 1999. TPC shares the water from this spring with the farmer-initiated irrigation area that lies in the Mawala village downstream of the estate. This area covers about 1100 hectares and smallholder farmers cultivate rice, maize, beans and horticultural crops. A large canal is supposed to carry a flow of 2.6 m^3/s from the spring to TPC, which has a permit to abstract 1.7 m^3/s. The remaining 0.9 m^3/s are to be used downstream by the Mawala irrigation scheme, which also has a formal water use permit. Before TPC took over, the previous estate used little water leaving almost everything to downstream Mawala farmers who steadily expanded their irrigated area. However, as TPC started abstracting more water to cultivate a larger share of its landholding, the farmers in Mawala started experiencing water shortage. This was further exacerbated by upstream pumping by other smallholders and water weeds blocking large sections of the canal. As TPC uses large electrical pumps, their water abstraction is not influenced by dropping water levels, but there is no indication that they are using more water than the allocated maximum amount. Over the last years, there have been several instances of violent conflict, with farmers setting fire to the sugar cane and attempting to damage the pumps. During interviews, Mawala farmers repeatedly stated that they felt they bore the brunt of water shortage, while TPC did not have to reduce their water use. As one farmer put it:

> We have a water right. And we, we are born here. Can we say that we have a water right if the investor is taking more water than we are? When the water reduces, the mzungu [white guy] should also reduce the water. Even now he is irrigating, and I have nothing (…) Where is my water right and where is the water right of the mzungu, are they different?

Similarly to the farmers in Nduruma, this farmer emphasizes the difference between Tanzanians and foreigners, implying that those born locally should be granted access to surface water. The same sentiment was expressed by another farmer, who, as in the Nduruma case, also called for TPC to switch to groundwater: "This canal should be for the people. And for him, he should dig his own wells". The financial situation of TPC also played a role in this case: "There is groundwater here. If the government could force TPC to use groundwater, that would be good. TPC is rich, they should invest". However, unlike in Nduruma, TPC has not started using groundwater in the part of the estate taking water from the spring. According to both farmers and government officials, TPC has refused to exploit its existing boreholes because it claims that the water is of inferior quality. However, the quality of this water, or the possibilities for tapping into a different groundwater aquifer, are not known to the PBWB. In addition, TPC currently experiences high levels of water security, as the spring has a continuous discharge and it has an upstream position. TPC's response to conflict has been to refer to its water permit, and treat it as a minimum guaranteed amount rather than a maximum abstraction, and to post

guards at the pumping station where water is lifted from the canal to prevent farmers from damaging the pumps.

The assumption that groundwater use is linked to large capital investments, as well as increasing conflicts between small and large water users have led to a discursive environment in which groundwater is a resource to be tapped by commercial agribusinesses while surface water is left to smallholder farmers. As of yet, groundwater is not considered an economically viable option by many smallholders, especially if there is still the possibility of exerting pressure to try and access (cheaper/free) surface water. In the Nduruma case, groundwater is only accessible through deep tubewells, an investment which is too big for farmers cultivating relatively low value crops. In the Mawala case, groundwater irrigation of rice is considered too expensive. The shift of agribusinesses to groundwater is promoted by agribusinesses, government officials and smallholders as a win-win, as more surface water is available for smallholder farmers and agribusinesses can peacefully secure the water they need. At the same time, the case of TPC and the Mawala irrigation area shows that the power of smallholder communities and the basin office to force a transition to groundwater is limited. Agribusinesses in the case study area are unlikely to use groundwater unless it leads to an increase in quality or quantity and the financial consequences are acceptable. Perhaps most importantly however, the lack of knowledge on groundwater quantity and quality and its interactions with surface water make it impossible to assess the future equity effects of groundwater use. The current uncritical stance of both communities and government when it comes to the possible impacts of increased groundwater exploitation on communities' water access make it unlikely that groundwater studies will receive priority in future.

DISCUSSION AND CONCLUSION

The groundwater use landscape in Tanzania is evolving into a situation whereby deep groundwater is for large users, while small users (farmers and households) rely on springs, streams and shallow wells for their productive purposes. Differentiated access to knowledge and technology determines who gets to use what water. For small users, the knowledge and labour needed to construct shallow wells are the first steps towards accessing groundwater. This approach is attractive because it is based on the use of cheap and simple technologies, and therefore requires little financial capital. This form of water access however, is only possible as long as the water table remains high: once the water level begins to decline, the cost of deepening and enlarging wells will be out of reach for most small users. Large-scale users on the other hand, have the required financial capital and knowledge networks to maintain their water access at greater groundwater depth.

The processes of gaining, controlling and maintaining access to groundwater in the city is strongly mediated by access to technology and private financial capital. Shallow wells are cheaper and therefore the only option for those who do not have sufficient financial capital, as it is difficult to obtain formal credit for drilling activities. However, these shallow wells are more vulnerable to pollution and dropping groundwater levels, thereby limiting the poor's access to clean and sufficient water. Therefore, although the law now allows everyone to obtain water permits if the intended abstraction can be shown to be environmentally sustainable and not to interfere with existing use, not all users have the resources to access deeper groundwater of sufficient quantity and good quality. In addition, while the basin water board possess the legal authority to regulate access, its capacity to do so remains limited because of lack of funding and personnel (the entire basin is covered by five hydrologists, out of which only two are hydrogeologists). This further jeopardises the sustainability of shallow aquifers. The use of stealth (e.g. illegal drilling on weekends) to access groundwater is one of the preferred options for actors, avoiding the costly process of acquiring permits. The city water supply authority however, uses its privileged connection with the ministry responsible for water, financial capacity and legal mandate to operate in the city to secure and maintain its groundwater access.

In Tanzania, this differentiated groundwater access is being reinforced by the prevailing water policy and regulations. In basins experiencing seasonal or periodic surface water scarcity, groundwater is emerging as the resource for the rich and is therefore being reallocated to commercial agribusinesses or urban water utilities with access to large financial capital. The smaller users are currently not experiencing any negative influence of the shift of large users to groundwater. They are made to believe that such reallocation in the short or even longer term may well be to their benefit. This being said, the agribusinesses are unlikely to use groundwater unless it leads to an increase in quality or quantity and the financial consequences are acceptable. Water permit implementation did not contribute to equitable and sustainable management of groundwater resources but it appears to be a good system to generate revenue for basin water offices. The lack of capacity to monitor compliance with the conditions attached to the water permits means that users can pump as much as they want. Even with limited evidence about immediate lowering of surface streams or groundwater tables, the trends and processes documented in this paper show how the current policy and regulation inadvertently creates spaces for asymmetric access to (good quality) groundwater resources in Tanzania.

The processes of groundwater access and exploitation described in this paper are not unique to Tanzania, it is similar to what is taking place in other parts of sub-Saharan Africa (see Adelana et al., 2008; Mumma et al., 2011; Pietersen et al., 2011) and elsewhere (for India see Srinivasan and Kulkarni, 2014). Much as groundwater resources are increasingly seen as a potential source of irrigation and domestic water in rural and urban areas, there are also widening access inequalities among users. It is important to understand the processes of groundwater access and assess how these are being reinforced by the prevailing policy and regulations.

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