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What's in a Name? Politicising Wastewater Reuse in Irrigated Agriculture

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ABSTRACT: Wastewater is increasingly being reused as a solution to water scarcity in agriculture. This article combines a literature review with an ethnographic study of water reuse in Dar es Salaam, Tanzania, to explore the field of wastewater reuse and what it is made to represent. The academic literature largely focuses on the practical challenges of wastewater treatment, while underlying political dynamics that contextualise the planning of, and control over, water flows remain largely unaddressed. Because people seek to take control over water through the manipulation of flows and qualities, wastewater reuse is inherently political. The study of water reuse practices in Dar es Salaam shows how water quality decline is co-produced with processes of urbanisation that cause inequalities in the urban waterscape. Farmers are subject to changes in the physical characteristics and normative understandings of the urban water system, yet do not have the power to reconfigure these to their own ends or challenge the way that their practices are portrayed. This paper shows the importance of politicising wastewater reuse and calls for a more diverse and emancipatory understanding of, and response to, water reuse in agriculture through interdisciplinary research and the collaborative production of knowledge and interventions.

KEYWORDS: Wastewater reuse, irrigated urban agriculture, water quality, urban political ecology, Dar es Salaam, Tanzania

INTRODUCTION

Cities are growing worldwide, especially in those areas where the effects of climate change are expected to be most severe. The adverse effects of historic growth and industrialisation fall onto cities in Africa and Asia that have lower capabilities to adapt to these climatic changes (UN, 2018, 2022; IPCC, 2022a; Maplecroft, 2022). In the context of this growing future uncertainty, agriculture faces the challenge of producing more food with less water. A combination of the physical challenges related to unpredictable rainfall, higher crop water demands, and the political negotiations around the reallocation of water put increasing pressure on food production (Garrick et al., 2019; Hommes et al., 2019). It is expected that conflicts between the urban and agricultural sectors will become more pronounced in an increasing number of watersheds (Flörke et al., 2018). When handling these conflicts, allocation generally prioritises uses with the highest returns per unit of water. Cities hold a powerful position in this regard, since agriculture is often seen as inefficient in both technical (large water withdrawals at low irrigation efficiencies) and economic terms (low economic productivity compared to non-agricultural sectors) (Molle and Berkoff, 2009; Komakech et al., 2012). Irrigation modernisation can only partially offset agricultural water losses; this is driving a search for nonconventional solutions to water availability in agriculture.

Over the last decade there has been a growing interest in the potential for wastewater reuse as a solution to water scarcity. The attractiveness of wastewater (which contains water, nutrients, organic matter, and energy) as a resource comes hand in hand with risks (to human health and the environment)

and this dichotomy contributes to wastewater featuring prominently on international policy agendas. Wastewater reuse has the potential to be an important economic asset in a largely publicly-funded sector (Drechsel et al., 2015; Hernández-Sancho et al., 2015) and plays a central role in the water-energy-food nexus that focuses on resource streams, their interconnections, and the need to move towards circularity and the closing of resource loops (Kurian and Ardakanian, 2015; Gremillion and Avellán, 2016; Qadir et al., 2020). The interest in wastewater as a resource was highlighted and extensively discussed when UN-Water addressed this water type as its 2017 theme. The World Water Development Report of UN-Water, entitled *Wastewater: The untapped resource,* argues for a paradigm shift towards seeing the potential for wastewater as part of a circular economy (WWAP, 2017). This line of thinking (which emphasises the optimisation of cross-sectoral resource use) is particularly relevant in the context of urbanisation, as interconnected resource pressures are concentrated in cities and urban growth is reconfiguring the urban – rural interactions around water and food (Scott et al., 2016). The urban use and subsequent disposal of water affect physical flows and water qualities in ways which are not only material but also symbolic. This reconfigured water is relatively stable as a resource (as there is no seasonality in wastewater production) and contains valuable nutrients (although these are not easily separated from the hazardous elements it also contains), which makes building links between cities and agriculture an attractive option.

Wastewater reuse, however, cannot be seen as having uncapped and untapped potential yet to be fully embraced. Wastewater reuse is already widespread, particularly in low-income countries where small-scale farmers rely on urban return flows for irrigation (Scott et al., 2004; Drechsel et al., 2010). The majority of these reuse practices take place without planning or regulation and are not acknowledged for their contribution to the circular economy and local food production. This raises questions about which types of wastewater reuse are accounted for and which practices are deemed to be either appropriate or unfit for the purpose. By posing the question 'What's in a name?', this article explores the meaning of 'wastewater reuse in agriculture' and what it is made to represent, both in academic literature and in the governance of day-to-day reuse practices. The analysis is guided firstly by the question of how end-users' (i.e. farmers') perspectives on wastewater reuse compare to and interact with dominant (expert) knowledge in the same field. And secondly, how this interplay of different understandings influences governance and actual reuse practices. Based on literature and my own experiences in the field, I start from the hypothesis that this expert perspective approaches water pollution and reuse predominantly as a biophysical challenge that can be resolved using technical solutions and good governance. Rendering these issues as technically solvable largely conceals the political nature of access to water quantity and quality. By studying water reuse practices in the rapidly-growing city of Dar es Salaam, Tanzania, this paper shows the value of a socio-political study of wastewater reuse to supplement these expert understandings. An interdisciplinary research engagement, in which both the biophysical and socio-political processes that configure wastewater reuse are studied complementarily, would thus contribute to a richer description of how water reuse takes shape and thereby allow us to engage with water reuse in more diverse and emancipatory ways.

Many cities' water supplies are characterised by heterogenous infrastructure configurations that result in differentiated conditions of access (Graham and Marvin, 2001; Crow-Miller et al., 2017; Lawhon et al., 2018; Rusca and Cleaver, 2022). These features shape the ways in which urban dwellers manage and navigate their way through the city. Urban political ecology has advanced the understanding of cities as interactive socio-ecological spaces that are shaped by social relations of power. Urban dwellers exercise their power to appropriate the city for their own ends through, for example, finding ways to gain access to scarce land and water resources. The capacity to mobilise power is contextualised both geographically and historically, which creates divergent socio-material geographies and social marginalisation (Heynen et al., 2006; Lawhon et al., 2014). Whilst urban political ecology scholars have focused extensively on access to water quantities and timing, little attention has thus far been paid to issues surrounding water quality decline (Rusca et al., 2017; Karpouzoglou et al., 2018; MacAfee, 2022). Rusca et al. (2017: 139) describe how water quality "continues to be entrenched in disciplinary studies in

micro-biology focusing on physico-chemical and microbiological quality and in studies in public health focusing on risks associated with contaminated water". Just as access to water can be a contested resource over which people seek to exert agency in order to maintain or upset control, water quality can be similarly contested. By applying a political ecology lens to understanding wastewater reuse practices, this paper shows how water quality is instrumental in understanding the varying levels of control that water users have within the urban waterscape.

First, this paper provides a literature review of the past decade of publications on wastewater reuse in agriculture. The research field is studied from three different angles: an analysis of the academic corpus, the global scale, and the most common descriptors. It shows that the academic engagement predominantly revolves around the biophysical aspects of wastewater and its reuse in formally structured schemes. This paper then describes the results of ethnographic research into water reuse practices in Tanzania's largest city, Dar es Salaam. Although this paper explores 'wastewater reuse in agriculture', it refers to 'water reuse in agriculture' in the case description, as the farmers' vocabularies deviate from commonly-used terminology to describe these reuse practices (I will come back to this in more detail). The case analysis shows the value of integrating a socio-political approach into the study of water reuse. The study employed participant-led research in six urban agricultural areas between May 2021 and July 2022, with regular field visits and active farmer engagement, in order to learn more about the everyday lives of urban dwellers who cultivate and irrigate and to understand how their practices are embedded in the wider urban context. This article mainly relies on regular interactions with sixteen farmers in one particular agricultural area. In addition, stakeholder interviews and documentary analysis were used to relate the field observations to the broader dynamics around access to land and water in a rapidly growing city. Finally, three insights from the analyses highlight the importance of politicising wastewater reuse and point towards a more diverse and emancipatory understanding of, and response to, day-to-day reuse practices.

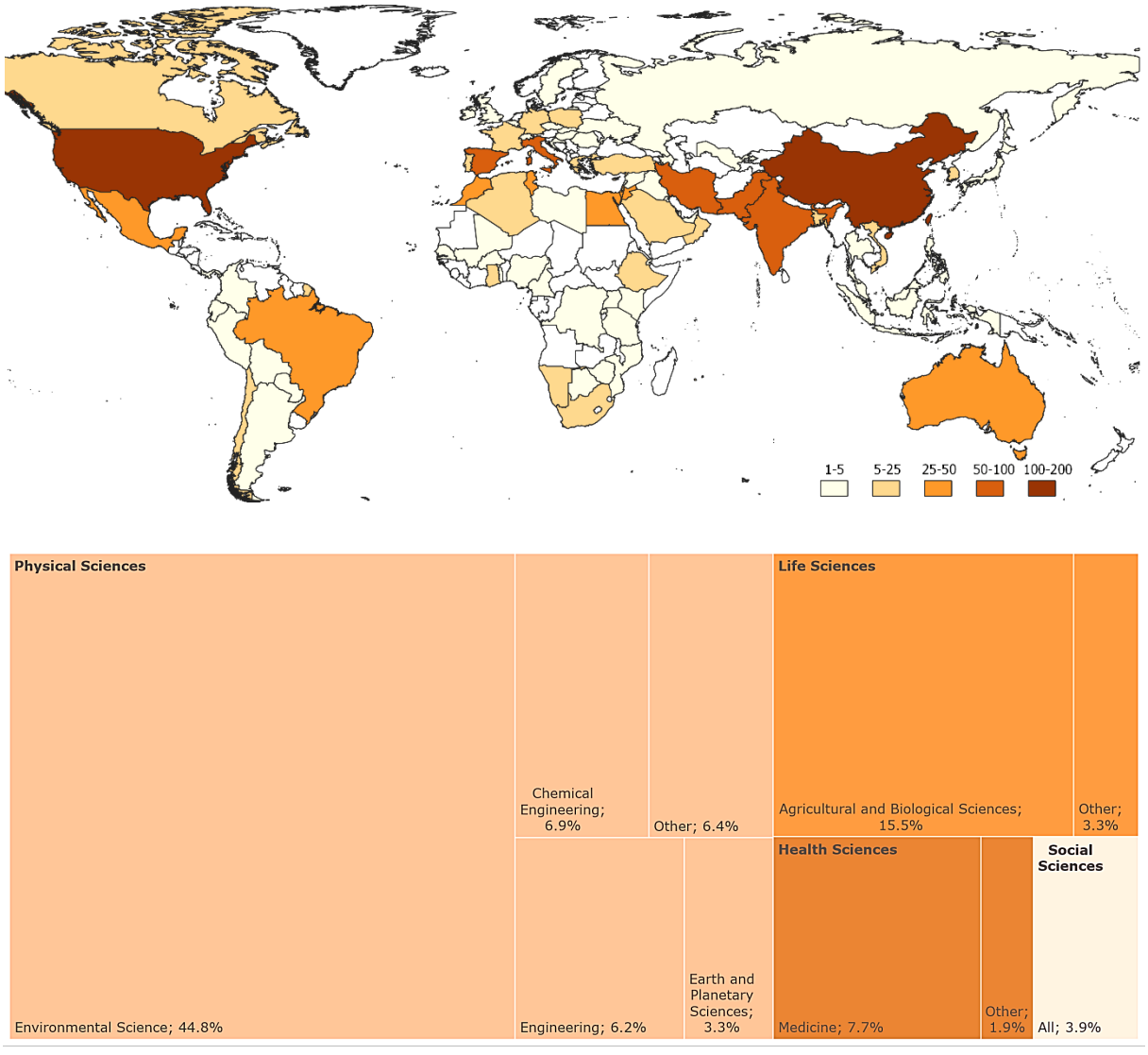
EXPLORING UNCHARTED WATERS

Three steps were taken to navigate through the academic field of wastewater reuse in agriculture. First, a bibliometric analysis was conducted to study the intellectual structure of the research field over the past decade (Donthu et al., 2021). Bibliometric techniques are increasingly used as a literature review method to map the conceptual and performative structures within a (broad) research field. In the field of water management this has, for example, been done by Zare et al. (2017), Velasco-Muñoz et al. (2018), and Durán-Sánchez et al. (2020). The resulting insights into the thematic and geographical characteristics of the research field are presented in this section. Second, the scale of wastewater reuse in agriculture is discussed in order to show the role that reuse plays in meeting water and food needs around the world. Third, and building on the previous steps, this paper shows a classification of wastewater reuse in agriculture based on influential publications in the field. Additional information about the literature review can be found in Annex 1.

There has been a growing academic interest in wastewater reuse in agriculture over the past decade, undeniably a result of increasing stress on global water supplies. Academic contributions are diverse in their focus, as the chain of water production leading up to agricultural reuse passes through different fields of attention, but most published articles (68%) belong to the physical sciences (Figure 1), with the environmental sciences being the largest field represented. Meanwhile, the social sciences make up the smallest contribution (4%), which shows a limited focus on the societal dynamics that surround water reuse. Publications predominantly centre around treatment processes and the biophysical effects of water reuse (both beneficial and harmful) for agricultural production systems. Close to half of all publications don't refer to a specific geographical context and apply research approaches that are not specific to a particular location (e.g. experimental set-ups or modelling-based approaches). Most publications that do refer to a geographical context (country or city) take place in North Africa and the

Middle East (Figure 1; Annex 1). Three quarters of all publications about wastewater reuse in a particular location take place in upper-middle- and high-income countries. This shows a relatively low representation of research work in regions that have a lower capacity to adapt to climate change. An increase in urban vulnerability and scarcity-induced economic losses in those areas puts more pressure on the competition over available water resources (IPCC, 2022a; 2022b). The absence of research work on wastewater reuse in these climate-vulnerable countries should not, however, be interpreted as an absence of reuse practices; rather, it shows how water reuse is neither monitored nor accounted for.

Figure 1. (a) Geographical distribution of location-based publications. (b) Thematic distribution of publications based on the All Science Journal Classification. More details are provided in Annex 1.



Non-conventional sources such as wastewater are believed to hold the potential to reduce the pressure on the global water budget – especially in the agricultural sector, which accounts for 72% of all freshwater withdrawals worldwide (FAO, 2021). Incorporating these 'new' sources into agriculture enables freshwater to be transferred to higher-value uses (such as growing cities) and contributes to the balancing of competing water demands among various users (Reznik et al., 2017; Li et al., 2019; Drechsel et al., 2022a). Thebo et al. (2017) calculate that around 35.9 million hectares of irrigated cropland have high

levels of dependence on urban wastewater flows, which is at least 50% higher than previous estimates. 82% of this cropland is located in catchments with low levels of wastewater treatment. Such settings are often described as unplanned wastewater reuse or wastewater irrigation (see below), and they are poorly accounted for in traditional water accounting approaches. Global or regional assessments of wastewater reuse often focus on the planned reuse of treated effluent and do not capture the significantly larger share of indirect reuse of untreated or partially treated wastewater flows, widely used in low- and middle-income countries (Drechsel et al., 2015). The scale over which the planned reuse of treated wastewater takes place is estimated to be between 0.7 and 1.35 million hectares and is particularly focused on the Middle East, North Africa, and Western Europe (Jones et al., 2021; Drechsel et al., 2022b).

Quantifying the scale of wastewater reuse in agriculture is a challenge given the different types of water use configurations. The practice has often been referred to as 'wastewater irrigation' (particularly in the unplanned setting) (Zhang and Shen, 2019), which creates uncertainty over whether it captures the diversity of water uses that have an impact on agricultural productivity, human health, and the environment. Wastewater itself already consists of a number of 'used' water flows that have been produced by households, businesses, or in industrial settings. Wastewater reuse is generally clustered into four categories: direct and treated, direct and untreated, indirect and treated, and indirect and untreated (van der Hoek, 2004; Huibers and van Lier, 2005; Jiménez et al., 2010; Mateo-Sagasta et al., 2015). With direct use, wastewater (treated or untreated) is used in agriculture without being mixed with other water flows. In the case of indirect use, wastewater is first discharged into a water body and used downstream. This indirect use dilutes the wastewater, as well as the meaning attributed to it. Linked to these clusters – which strongly focus on the treatment and disposal/reuse component of the wastewater management chain – there is often reference to the level of planning involved. Drechsel et al. (2022b) expand on earlier work by Scott et al. (2009) and differentiate between planned and unplanned wastewater reuse. Planned wastewater reuse is generally linked to the direct reuse of treated wastewater, with strict regulation and high levels of formal recognition. These reuse configurations generally move away from pointing at the waste character of the water used by referring to 'reclaimed' or 'recycled' water. Such changes in semantics have a proven positive impact on the perception of risk involved in wastewater reuse (Mikhailovich, 2009; McClaran et al., 2020). Unplanned wastewater reuse, meanwhile, is mostly associated with the indirect use of (partially) untreated water in an informal setting. These practices are typified by other descriptors, such as wastewater reuse or wastewater irrigation – terminologies that do not necessarily match the perspectives of the end-users themselves, as I will show in the next section.

This section demonstrates the prevalent academic focus on the biophysical aspects of wastewater reuse in the context of the planned (and regulated) connection between wastewater management and irrigated agriculture. The deterioration of water quality due to prior use is controlled by treatment set-ups and the monitoring of quality parameters in order to minimise any negative impacts on crops, human health, or the environment. Planned reuse schemes allow for a controlled environment that seeks to optimise the productive and economic benefits of transforming this waste stream into a resource. However, the socio-political dynamics that contextualise the planning of, and control over, water flows remain largely unaddressed. Beveridge et al. (2017) describe how social science studies in the field of water reuse only focus on particular problems around implementation and largely overlook the politics of water reuse. Whereas research approaches show a dominant focus on water quality control backed by technical expertise, this paper rather continues by giving insight into the socio-political processes that configure access to water flows and qualities.

WATER REUSE IN DAR ES SALAAM

Wastewater reuse in agriculture takes place around the world, but research is largely focused on planned reuse, the associated water treatment, and regulative institutions. State authorities play an important

role in these water systems, whereas farmers participate with varying levels of control. Meanwhile, a far greater share of water reuse takes place on a more informal basis where farmers (consciously or unconsciously) make use of urban water flows for irrigation in urban, peri-urban, or rural areas downstream of cities. Although commonly classified as 'unplanned', farmers actively and intentionally plan their use of water for agricultural purposes – though largely without any state involvement. This section examines such cultivation and irrigation practices in Dar es Salaam and shows the multiple ways of knowing and doing that surround water reuse. By taking day-to-day reuse practices as an entry point, I show how the farmers' perspectives on water reuse compare to and interact with dominant (expert) knowledge. A focus on the farmers' everyday dealings with water thus widens and pluralises the understanding of water reuse.

Irrigated urban agriculture is a long-established part of Dar es Salaam, is responsive to urban growth, and functions independently from the state. Open spaces – such as river valleys, flood-prone areas, public open spaces, or to-be-developed private plots – serve as (often temporary) opportunities from which networks of food provision are built. Leafy vegetables are commonly found in these areas, as they are in high demand, quick to grow, and perishable (which favours short distances between producers and consumers). Wegerif (2017) describes how urban farmers are part of a symbiotic food system that provides economic opportunities for a range of people and an accessible supply of fresh vegetables for consumers. The ability to construct (and reconstruct) a network of food provision that fits the urban ecosystem has enabled its continued presence, but farmers are also subject to the changes that occur around them. The densification and expansion of the city pose a constant risk that the opportunity to use land will be lost. Since agricultural land is regarded as inferior to other uses, zoning urban land for agriculture is uncommon. Urban farming persists in Tanzanian cities as long as it is deemed appropriate, but it is seen as subservient to other uses when they present themselves (Foeken et al., 2004; Msangi, 2011; Mlozi et al., 2014; Namwata et al., 2015; Mkwela, 2016; Thomas et al., 2021). "Urban agriculture is placed at the bottom of the pile as a land-use priority. The best land is often covered in concrete whereas the poor land is rehabilitated for food production" (Hallett et al., 2016: 94). Farmers in and around African cities often have a limited say in the urbanisation agendas that are imposed on them (Zoomers et al., 2017). Since the majority of agriculture in Dar es Salaam relies on informal agreements for land access, farmers are constantly exposed to urban land grabbing.

The Msimbazi River is the city's largest river and is also known for the agricultural production in its floodplains. The river originates in the city's adjacent rural region and is joined by a number of tributaries before flowing into the Indian Ocean. It receives effluent discharges from residential areas and several industrial sites as it passes through the city (Leonard et al., 2012; Chanzi, 2018). During the dry season, the baseflow from the hinterland is low, and the supply of water is believed to be largely return flows from human activities. Some of these return flows are treated (the river receives effluent from several wastewater treatment plants), but other wastewater flows are discharged directly into the river. The best-known agricultural area along the river is called Sukita (around 45 hectares, and largely used for agriculture). Sukita is named after the business arm of Tanzania's ruling political party, which previously managed the area as a coconut plantation and allowed farmers to grow vegetables under the palm trees as a way to keep the area clean and looked after (a common reason for urban landowners to allow agriculture on their land). The agricultural area – enclosed by high-density informal settlements – has remained part of the city for over 40 years, as annual flooding prohibits construction in the area. However, urban development is still occurring: several warehouses have been built there over the last decade, eating up agricultural land, and the placement of beacons by land surveyors in more recent years has given farmers reason to fear imminent eviction. Since there is no formal recognition of agricultural land use in the city, land pressure is slowly forcing farmers to relocate to the edges of society, both physically and ideologically speaking (Bersaglio and Kepe, 2014). This means that farmers in Dar es Salaam who lose agricultural land to urban development move towards the peri-urban areas or into marginal areas such as Sukita.

The urban dwellers who practice farming in Sukita and other agricultural areas in Dar es Salaam rely on informal land use agreements. Men generally have a stronger hold over the land, although this does not reflect the important role that women play in food production and provisioning. When visiting Sukita in the early morning, one finds female farmers and groups of women harvesting and preparing vegetables (washing, sorting, bundling) and leaving the area to sell at markets and vegetable stalls or to go from door to door in the surrounding neighbourhoods. A small portion of the vegetables is sold directly to consumers who visit the area. This small-scale, commercial agriculture provides a reliable household income, and only a small number of farmers combine their farming activities with other jobs (e.g. security or construction). Nearly all farmers in the area are rural migrants who spent, on average, 6 to 7 years in the city engaged in other types of employment before starting agriculture. Social organisation among farmers remains low due to their social heterogeneity; their different ethnic backgrounds, socio-economic characteristics, areas of urban residence, and agricultural aspirations make it difficult for urban farmers to organise themselves as a group. The sparse social organisation that is present generally revolves around occasional matters that endanger farming practices, such as conflicts around access to land and water or water scarcity during the dry period. The mobile petrol pumps that are used for irrigation are generally individually owned, as farmers are afraid of the potential conflicts that collective ownership might cause. It is more common for women farmers to lend out a pump (on the condition that their own plots are also irrigated), as pump irrigation is regarded as a physically demanding job that should be done by men.

Over time, Sukita has become symbolic of the conflictive relations between agriculture and the city. Water quality studies have shown pollution in the Msimbazi River, with specific focus on the concentration of heavy metals, which exceeds permissible limits (Mwegoha and Kihampa, 2010; Leonard et al., 2012; Harieth, 2017; Chanzi, 2018). Heavy metal contamination has also been found in the vegetables grown along the river (Kihampa and Mwegoha, 2010). An increase in the number of uncontrolled industrial and domestic discharges has led to this deterioration. Over two million people in the city were estimated to be possibly exposed to severe health risks given the river water pollution and the fact that the leafy vegetables grown in the river valley are consumed by nearly all citizens (Leonard et al., 2012). Such figures and other research outcomes have been widely picked up and have resulted in a number of newspaper articles with alarming titles such as "Dar's river pollution threatens millions" and "Vegetables in city gardens declared as silent killers" (Andrew, 2008; Sylvester, 2018). Farmers in Sukita – as well as in other agricultural areas – contest these statements and indicate that these articles have raised disproportionate concerns about vegetable production in Dar es Salaam. However, a shut-down of urban farming as a consequence of this uproar is uncommon, given the significant number of urban dwellers that either directly or indirectly benefit from local vegetable production. Local government authorities have only decided to shift their focus to other areas that don't face the detrimental effects of urbanisation and are therefore more popular (or less sensitive) to engage with. This can be seen in the side-lining of Sukita during discussions about the formalisation of urban agricultural areas (McLees, 2012), a municipal council that indicates not to provide extension services to agricultural areas facing problems with water pollution (p.c. L6[1]; 23 July 2021; Y7, 12 April 2022), and an observed shift of extension services towards peri-urban agriculture and more advanced agricultural set-ups.

Most research thus far has been conducted on the biophysical characteristics of the Msimbazi River, linking them to the farmers present in the river's vicinity without studying actual farmers' practices. However, active farmer engagement and field observations have revealed that the understanding of water flows and qualities in Sukita is more diversified than previously documented. Farmers do not rely solely on the Msimbazi River for their water, but also make use of a network of canals and a number of shallow wells. The (unlined) canals play a particularly important role for the majority of farmers whose plots are not directly adjacent to the river. These canals originate in the residential areas and feed

[1] P.c. refers to 'personal communication'. The names of all interviewees are coded to protect their identities.

reservoirs that increase the buffering capacity of the local water scheme for times when irrigation demand exceeds water supply. The canals from the urban areas drain a combination of water flows, which reflect the composition of the area. Observations and interviews indicate that most water drained into the area is domestic wastewater, stormwater, and water leakages from the piped water system. Some of these leaks get repaired, while other background leaks are hard to identify or contain and are a possibly significant contributor to a stable base flow into the area.[2] Industrial wastewater (which is often cited in the case of the Msimbazi River) is not a significant source for most of the canals that the farmers use. The other source is a number of shallow wells supplied with water from the shallow groundwater table in the area; these also fill up during rainfall events. The latter is a known challenge in terms of water quality, as floods flush waste towards low-lying areas.

When asked to characterise their own irrigation sources, farmers described them in terms of quantity and reliability, and (upon further probing) the majority indicated that they did not experience problems with water quality. Three farmers referred to quality-related problems with the Msimbazi River (skin irritation and two cases of detrimental crop growth) (p.c. C6, 20 July 2021; J7, 19 August 2021; W2, 19 August 2021). When asked about changes in water quality, farmers indicated that the increase in the numbers of households and industries discharging wastewater into the river has affected the water quality compared to when they started using the area. Changes in the quality of water from canals and shallow wells were not mentioned during these interviews. Observations in the area indicate that the water from these different sources can have different colours and can sometimes smell when pumped but does not seem to be detrimental to plant growth. The vegetables grow well across the whole area and show no visual abnormalities. Interviews and observations in other urban agricultural areas in Dar es Salaam also show deterioration in the quality of available water, but no visible problems with crop growth. It is uncommon for farmers to raise concerns around the quality decline of their irrigation sources, because the use of urban water flows is not formally acknowledged and has already contributed to controversy around the presence of agriculture in the city. Since farmers are unable to advocate for the preservation of their irrigation sources (or land security), they employ a strategy of persistence in which they limit their engagement with authorities as a way to be of limited disturbance while continuing with their irrigated cultivation practices. Farmers only raise concerns when there is a risk of losing access to water quantity (or to the land itself), but they tend to accept the water quality decline they are confronted with.

Research and media attention has contributed to a public perception that farmers are putting consumers at risk. Fifteen farmers in different agricultural areas throughout the city were asked to respond to this issue (phrased as, "Farmers are putting the people of Dar es Salaam at risk because of their use of wastewater for irrigation"). Three types of responses were given. The first and largest group of farmers responded by saying simply that their water is clean and safe to be used for irrigation. Their position is derived from the fact that they have not experienced problems with their cultivation nor received complaints from their buyers. The second group acknowledges pollution in their respective areas but argue that they are unable to switch to alternative sources. One of the farmers explained: "I usually reply with a 'sorry', as we do not have any other choice for water. There is no way to prevent discharges from getting into the canal" (p.c. B8, 9 July 2022). Another farmer similarly responded that "there is no such thing as clean water in Dar es Salaam" (p.c. S1, 7 July 2022) and that he and his fellow farmers have no option other than to use the water that is available. Finally, a few farmers argued that these rumours are spread by those who wish to discredit their activities, as they don't like to see agriculture in the city or have a commercial interest in importing vegetables from outside the city. There is a strong feeling among farmers that it is wrong to blame them for water quality problems and that

[2] 38.8% of all water produced by DAWASA (Dar es Salaam's water utility company) is lost through a combination of physical and commercial losses and becomes (partially) available in the catchment (EWURA, 2022).

instead of criminalising the cultivation of vegetables, local government authorities should stop unlawful wastewater discharges upstream (see Figure 2).

Figure 2. Illustration based on research conducted in the area. Farmers feel that the government is criminalising the cultivation of vegetables rather than responding to unlawful pollution upstream.

Farmers do not deny that water pollution is affecting their water sources, but at the same time, they don't like to refer to their irrigation sources as 'wastewater'. They don't experience the water they use as harmful for production and believe that the term 'wastewater' is pejorative and problematic for their business. Examples from field work, though anecdotal, show that farmers use different descriptions for their water sources. When asked where the water from their canals originated, several farmers used the term *chemchem,* a Swahili word that refers to a natural spring. While this protects them from disclosing further information about the source, it also has interesting linguistic overtones. In the urban context, it is an anthropogenic, rather than a natural, source that supplies farmers with a stream of water. Irrespective of a rural or urban setting, *chemchem* refers to a place where water wells up that can be used for irrigation (p.c. N1, 29 July 2021; W2, 19 August 2021; A4, 28 June 2022; informal conversations 16 June 2021, 19 August 2021). Another farmer consistently referred to his irrigation water as *maji ya Bongo (Bongo* is a nickname for the city, so this translates as 'water of Dar es Salaam') during our regular interactions in the field throughout the research period (p.c. B2). He justified this by explaining that there was no other way of knowing or describing the water he used, since it is urban water constituted by a multiplicity of upstream uses (and misuses).

Taking the farmers' everyday dealings with water as an entry point, this section shows how farmers' practices are persistent despite being suppressed, and why governing water reuse practices is not a technical, apolitical challenge. The availability of leafy vegetables for consumption in Dar es Salaam largely relies on self-organised systems of irrigated urban agriculture based on the (temporary) use of vacant land and a variety of urban water flows. Empirical data from Sukita shows how irrigation is deeply entrenched in this urban water system and subject to changes that occur elsewhere in this system. Farmers make use of different irrigation sources that are fed by a combination of urban water flows. Different vocabularies are used to describe these water flows compared to common expert perspectives, as farmers believe that the term 'wastewater' is pejorative and problematic, particularly while they have

no control over changes in water quality that occur. Although they are actively responding to the opportunities of urban land and water, farmers have limited agency in setting the conditions of their (hydraulic) citizenship, since the presence of agriculture in the city is disputed. They are subject to relocation towards more marginal areas and face a deterioration in the quality of their irrigation sources due to upstream uses. Moreover, they have little or no control over either of these factors, both of which marginalise them and their livelihoods. This shows the inherent political nature of water reuse, as people have varying levels of control over, and access to, water – both flows and qualities – and the associated normative understandings of this water use. The following section reflects on the lessons that can be learned from studying the politics that surround such water reuse configurations.

DISCUSSION

The preceding sections studied wastewater reuse in order to better understand what it is made to represent, both in academic literature and in day-to-day practices in Dar es Salaam. Linton (2010) introduces his writings with the assertion that "water is what we make of it", which is helpful here in discussing what is made of wastewater (and its reuse). Although wastewater holds the potential to reduce urban vulnerability and scarcity-induced economic losses in areas that are prone to climate change, this attractive narrative risks boiling water reuse down to a managerial task that does not acknowledge the tensions intrinsic to water control. Based on the previous sections, I highlight here three insights that show both the importance of politicising wastewater reuse and also how this politicisation can contribute to more diverse and socially just responses to water reuse in urbanising landscapes.

Firstly, the literature review of the academic field shows a dominant focus on the physical processes that surround water quality. Wastewater reuse (and the associated control over water quality) is approached as a phenomenon that can be measured and managed in order to optimise its allocation. The exclusivity of this discourse can make the control of water (both in terms of quality and quantity) appear to be a politically neutral issue that can be solved through technical knowhow, rational water use, and good governance, rendering the role of power and politics invisible (Li, 2007; Boelens et al., 2016; Karpouzoglou et al., 2018; Wessels et al., 2019). However, water is more than its biochemical constituents that can be regulated through problem-solving interventions. It is surrounded by "valuations, knowledge and classifications that are contextual, complex, contested and/or sometimes ambiguous" (Berry et al., 2018: 40). Wastewater reuse is inherently political, as people seek to take control over water through the manipulation of physical flows and qualities. These reconfigured flows and qualities subsequently guide human behaviour and provide the conditions for management and regulation (Mollinga, 2008; Beveridge et al., 2017). Stakeholders do not only have differing perspectives and interests that can be subject to negotiation and conflict, they "are also drawing on different resources, norms and legal repertoires to articulate, frame, and defend their positions" (Zwarteveen et al., 2017: 6). The case analysis in this paper complements common academic focuses by shedding light on the socio-political processes that configure water reuse practices. Urban agriculture in Dar es Salaam serves as an (informal) food and job provider in a changing urban landscape, but those who practice farming are limited in their power to configure the socio-material environment according to their own needs. Lacking formal recognition of their presence, farmers are slowly relegated to fringe areas and forced to use marginal water sources. In order to continue their activities and provide the city with vegetables, they minimise the voicing of their concerns whilst, at the same time, bearing the public disapproval associated with water quality decline, which they cannot control. Studying the farmers' everyday dealings with water clearly shows the deeply political processes that shape what the city looks like or how water flows (and with what quality). To contribute to the understanding of water reuse in agriculture, this paper calls for an interdisciplinary research engagement in which both the biophysical and socio-political processes that configure wastewater reuse are studied complementarily. Besides this, pluralising the scholarship by looking beyond accepted science-based expertise to learn from the many other voices, experiences, and stories

associated with wastewater reuse can help us make sense of, and engage with, day-to-day water use (Zwarteveen et al., 2021).

Secondly, the empirical case on which this paper is based shows how urban farmers have limited control over the quality of the water that they tap into. This limited control over the conditions of their (hydraulic) citizenship is not unique for Dar es Salaam; farmers in other African cities face similar contestations around their presence and practices. Governments and international donors play an important role in foregrounding ideas on progress, modernity, and development, which depoliticise underlying questions about who has a right to the city (and under what conditions) (Watson, 2014; van Noorloos and Kloosterboer, 2018; Côté-Roy and Moser, 2019). Urban political ecology has convincingly shown that urbanisation trajectories are infused with power relations which shape who has access to, or control over, urban water (e.g. Swyngedouw, 2004; Heynen et al., 2006; Lawhon et al., 2014). While urban political ecology work has largely focused on access to water quantities and timing, this paper shows how water quality can be similarly studied as a measure of uneven access to water. Rusca et al. (2017: 140) describe how water should be recognised in "the sets of social relations that produce water as a commodity (thereby shaping uneven access to that commodity) but also on the socio-ecological relations that give rise to wide variations in water quality and to the exposure of certain groups to poor quality water". Water quality can be instrumental in the study of inequalities in the urban waterscape but requires a comprehensive understanding of both the biophysical and socio-political characteristics of water reuse. Addressing these inequalities in planning and regulation will mean recognising farmers as active participants in the urban water system (with the privileges and responsibilities involved) rather than mere recipients of water 'wasted' elsewhere. However, having farmers actively partake in the planning of urban land and water also requires recognising agriculture as part of the city's future – something that is contested. By co-producing knowledge and interventions, participative governance can contribute to improving urban food safety and security, which benefits both producers and consumers.

Thirdly, this paper shows the knowledge and values that farmers attribute to the water that they use and how this compares to dominant expert framings. Where these types of water reuse configurations are often referred to as 'wastewater irrigation', this case study shows how this terminology is arbitrary compared to the multiplicity of water flows being reused. Farmers make use of different sources, which are fed by a combination of urban water flows. Although the importance of wastewater flows (including untreated) should not be rendered insignificant, the use of 'wastewater' as an all-encompassing term does not give recognition to the diversity of the flows nor the perspectives of the users themselves. Water is not universally understood: different actors mobilise different ways of thinking and understanding that lead to differing representations and discursive constructions of water. In the case of Dar es Salaam, farmers refer to their irrigation water as a resource rather than a waste product, despite being aware that the water has often been used before. The reference to 'wastewater reuse' or 'wastewater irrigation' by experts to describe these water use practices marginalises farmers and their views on water, which contributes to the persistence of knowledge inequities. Related to this is the common classification of the great majority of water reuse worldwide as 'unplanned'. In actuality, the farmer-led irrigation development that takes place is intentional and requires hard work and investment. Referring to this farmer-initiated development of water reuse as informal, unofficial, or unplanned "labels them as inferior, and often indirectly calls for an intervention to regulate it" (Veldwisch et al., 2019: 4). A richer and more nuanced description of water reuse – for example, that dissects the diversity of the urban flows that feed irrigation sources, recognises end-users' views on irrigation sources (by, for example, taking the 'waste' out of 'wastewater'), and acknowledges the intentional efforts of farmers to reuse water – better captures day-to-day realities and thereby allows a more emancipatory engagement with water reuse.

Summing up, this article shows the value of politicising wastewater reuse by studying the biophysical and socio-political processes of water as complementary. While water is a single compound, understandings of it are plural. This means that there is no consensus among actors as to what wastewater reuse represents. Multiple knowledges about wastewater reuse co-exist, but the knowledges

embedded in the experiences of day-to-day water users are generally subordinated to the understandings of experts that prevail in research and governance. From an expert perspective, wastewater reuse predominantly revolves around the management of physical water flows and qualities through technical knowhow and regulatory guidelines. Showing the farmers' knowings and doings pluralises the understanding of water reuse in agriculture. Farmers actively and intentionally plan their use of water for agricultural purposes, but they are limited in their control over the physical quality of the water as well as the normative attributes associated with the practice, i.e. they have no control over 'what is made of water'. The call for an interdisciplinary research engagement and the pluralisation of wastewater reuse scholarship is not bound to the particular sphere of water reuse described here but also extends to the other water reuse typologies, regardless of the fact that the politics elsewhere may be configured differently. Wessels et al. (2019) and Tawfik et al. (2023), for example, show how farmers in South Africa and Jordan, respectively, exert power to align the biophysical and socio-political arrangement of water reuse according to their own interests (with varying levels of success). By considering the power-laden context of water reuse, planning water reuse as a solution to growing water scarcity can also serve as an opportunity to reduce socio-economic inequality and political exclusion.

CONCLUSIONS

This article poses the question 'What's in a name?' to explore what wastewater reuse in agriculture is made to represent, both in academic literature and in farmers' everyday dealings with water reuse. The academic field largely focuses on the biophysical control of water in order to optimise reallocation for subsequent use. The use of nonconventional waters herein answers to allocation gaps that cause economic losses to society. Wastewater flows are approached as a practical challenge that can be managed by designing adequate treatment and good governance. However, the control of water can be subject to negotiation and conflict, as various actors exert their power to align water use and quality with their own interests and convictions. This power capacity results in inequalities in the waterscape that are insufficiently addressed in the field of wastewater reuse. Studying the socio-political processes that configure water reuse in Dar es Salaam, Tanzania, highlights the different water knowledges, values, and interests that surround water flows and qualities. Farmers tap into a variety of urban water flows and attribute different types of knowledge and values to the water they depend on than compared to the expert framings prevalent in research and governance.

Since the presence of irrigated agriculture is not formally acknowledged in the city, farmers are the mere recipients of waters 'wasted' elsewhere. They are subject to changes in the physical characteristics and normative understandings of the urban water system, without holding the power to reconfigure these characteristics to their own needs or to control how their practices are portrayed. This paper calls for an interdisciplinary research engagement in which the biophysical and socio-political processes of water reuse are studied complementarily, as well as pluralising the wastewater reuse scholarship by looking beyond expert understandings of water to learn from the knowledges and interventions that farmers have devised. Putting the end-users central to the study of, and responses to, water reuse contributes to a richer and more meaningful description of everyday reuse realities and thereby allows water reuse to acquire a more emancipatory nature. The collaborative production of knowledge and interventions could empower those who, though generally not regarded as professional experts, are already developing solutions on a day-to-day basis to productively reuse water and strengthen horizontal and collaborative relationships within the city.

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ANNEX 1. DETAILS OF LITERATURE REVIEW

Table 1. Details of the literature review

Research topic Wastewater reuse in agriculture
Electronic database searched (date: 09-01-2023) Web of Science
Search terms used (content fields title-abstract-author keywords) ((reuse OR recycl* OR reclaim*) NEAR/5 (water OR wastewater OR effluent OR sewage) NEAR/10 (agricultur* OR irrigat* OR crop*)) OR ("wastewater irrigation" OR (wastewater NEAR/5 use NEAR/10 agriculture)) AND NOT ("agricultural waste" OR "agricultural wastewater" OR "agro-wastewater" OR slurry OR manure OR "crop residue" OR "agricultural residu*" OR "agricultural drainage" OR "produced water" OR "oil and gas" OR "mine water" OR "mine wastewater")
Article selection Document type: article Document language: English Period: 2013-2022
Article screening Web of Science: 2454 Screening out duplicates and records without content: 2446 Manual screening out of non-municipal wastewater production[1]: 2396

[1] Manual screening was done to evaluate (and omit) records that focus on wastewater reuse with a different definition of wastewater than that used in this paper. Examples include records on agricultural wastewater (e.g. drainage) and non-municipal industrial wastewater (e.g. oil and gas extraction effluent). The keywords used in the search of the title (TI), abstract (AB), and author keywords (DE) were 'drainage', 'mine', 'gas', and 'oil'.

Table 2. Summary of the bibliometric database.

Description	*Results*
Documents	2396
Annual growth rate	8.7%
Average document age	4.7 years
Average citations per article	14.7
Most popular journals	Science of the Total Environment (n = 136); Agricultural Water Management (n = 118); Water (n = 111); Desalination and Water Treatment (n = 79)

Distribution by region[2]	Middle East & North Africa (n = 288); Europe & Central Asia (n = 251); East Asia & Pacific (n = 247); South Asia (n = 151); North America (n = 142); Latin America & Caribbean (n = 110); Sub-Saharan Africa (n = 73)
Distribution by income[2]	High income (n = 500); Upper middle income (n = 443); Lower middle income (n = 280); Low income (n = 39)

[2] 1134 publications don't have a reference to a location (countries, cities, or US states) based on title, abstract, or keywords.

Figure 1a. Locations were extracted using a semi-automated analysis of the title, abstract, and author keywords. Out of 2396 publications, 47% were not location-specific. This group primarily consists of experimental set-ups or modelling-based approaches that don't have a direct geographical locus. A small number of articles (< 50) were omitted since they had a regional focus (e.g. Europe). Articles with multiple countries have been attributed to one of the countries. The accuracy is > 98% based on manually checking a 10% random sample.

Figure 1b. 2389 publications were linked to the All Science Journal Classification code as listed in the Scopus Sources List (7 records were omitted). The publications in each journal were multiplied by the relative weight of the journal's subject areas. The sum of every subject area represents the relative proportion of publications of the total database in this respective subject area. For readability, all subject categories < 2.5% are grouped per scientific field.