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ORIGINAL ARTICLE

Institutional framework in relation to the use of low-quality water for food crops irrigation in Tanzania

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Abstract
Low-quality water as an alternative source of water for food crops irrigation is gaining popularity in urban and peri-urban area in developing countries. The practice is associated with health risks if appropriate institutional measures are not undertaken. It is unclear on whether and how the practice is incorporated in the existing institutions in Tanzania. A cross-sectional study was undertaken in the country to assess an institutional framework in relation to the use of low-quality water for food crops irrigation. Data were collected through documentary review of formal institutions, in-depth interviews with the government officials ($n=15$), farmers survey ($n=30$) and focus group discussions ($n=2$) with people using low-quality water from the waste stabilization ponds. Content and descriptive statistics analyses were employed. It was found that, the existing institutions (policies, legislations and regulations) lack provisions that explicitly support or oppose the use low-quality water for food crops irrigation. The current effluent standards are tailored towards safe disposal for environmental management and public health protection. However, water scarcity and the need for alternative sources of water were acknowledged in the institutions and by the government officials interviewed. The existing informal uses of low-quality water reported were vegetables irrigation, brick-making and drinking water for livestock though the government officials interviewed were not in favour of leafy vegetables irrigation. The study recommends formulation of new institutions or review of the existing ones to enhance the productive use of the water resource while protecting the health of the public and the environment.

Keywords Wastewater reuse · Treated wastewater · Institutions · Urban farming

Introduction

Population trends show that urban growth rate will be higher in developing countries than in the developed countries. Africa's urban population is likely to nearly triple between 2018 and 2050; by 2050 urban dwellers in Africa will be 1.5 billion (UN 2018). The population trends further show that within the developing countries the fastest growth in urban population will occur in sub-Saharan Africa. Andersson et al. (2016) and Miller-Robbie et al. (2017) point out that, increase in urban population will lead to an increased generation of large amount of wastewater together with raising the need for food to meet the increasing demand. Due to increased urban population, urban and peri-urban farming will continue to get prominence for the urban poor families as a source of food and income while utilizing the market opportunity for the demand of fresh food stuffs existing in the cities (Kalavrouziotis et al. 2011; Kopiyawattage et al. 2019). On the other hand, food crops production in urban and peri-urban areas depends on irrigation but water for irrigation as opposed to other uses is limited (Mukherjee et al. 2015; Jaramillo and Restrepo, 2017; Miller-Robbie et al. 2017; Faouzi et al. 2020; Helmecke et al. 2020). This situation makes low-quality water to be of great use not only because it is easily available but also as a dependable source of water for food crops irrigation in urban and peri-urban areas. In this study, the phrase low-quality water (LQW) is used to connote to the effluents discharged from the waste stabilisation ponds (WSPs). Waste stabilisation ponds are shallow basins that use natural factors such as sunlight, temperature, sedimentation, biodegradation to treat wastewater or faecal sludge (WHO 2006). In this study, LQW is synonymously used with treated wastewater.

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Low-quality water use in agricultural production is associated with health risks that differ in nature and magnitude depending on the level of wastewater treatment (WHO 2006; Jeong et al. 2016). Wastewater treatment to the required quality standard for a particular use in agricultural production is crucial as far as health protection is concerned. According to WHO (2006) and Jeong et al. (2016), the quality of treated wastewater depends on the nature of wastewater, irrigation methods, treatment technology and the dilution of treated wastewater. Therefore, the use of LQW in food crops irrigation has potential to cause health problems in the absence of proper management practices (Abunada and Nassar 2015; Najafi et al. 2015). Despite the health problems associated with LQW irrigation, the practice is a reality that cannot be denied due to growing water stress worldwide (WHO 2006; Scheierling et al. 2011). This is because farmers in urban and peri-urban areas of nearly all developing countries who are in need of water for irrigation have often no other choice than using LQW. The supply of potable water in urban and peri-urban areas to meet the domestic uses and irrigation farming is limited due to low pace in water services delivery development to meet the increased population (URT, 2002; Fraiture et al. 2010; Qadir et al. 2010; Faouzi et al. 2020). Low-quality water provides a reliable source of water in dry seasons, permitting production of multiple crops throughout the year. Production in the off-season, when dry season farming is limited also gives urban and peri-urban agriculture a competitive advantage. For example, in the Middle East countries, the use of LQW has become part of the integrated water resources management (Ensink et al. 2002; Shomar and Dare, 2015; Bahadir et al. 2016). According to Ensink et al. (2002), the use of LQW is a common practice in Saudi-Arabia, Jordan, India, Pakistan and Israel, with Israel taking the lead. Irrigation with LQW if properly managed contributes significantly to sustaining livelihoods, food security and the quality of environment (Keraita et al. 2012).

In view of this, several guidelines on the use of LQW in agriculture have been developed from time to time. The recent WHO (2006) guidelines propose procedures adaptable to specific circumstances to maximize overall public health benefits and the beneficial use of scarce resources. These guidelines are global in nature and can be used as benchmarks in developing the country specific guidelines. WHO (2006) guidelines suggest that adequate capacity is required at the national level to maximize the benefits of the use of LQW in agriculture, to minimize the health risks involved and to promote proper environmental management in ensuring long-term sustainability. This implies the need of creating or adapting an enabling institutional framework. This study defines institutional framework as law or other formal provisions that assign responsibility and authority to an actor (Matt, 2007; Ostrom 1990). On the other hand, institutions in this study are defined as systems of rights, rules and decision making procedures (Young et al. 2008). This study focuses on formal institutions which entail the state based rules of the game governing the use of LQW in food crops irrigation. It includes Policies, Acts, Regulations, Guidelines and By-laws. As the contribution to WHO (2006) guidelines this study generates information on the existing institutional framework for the practice in Tanzania. Weckenbrock et al. (2011) pointed out that addressing LQW irrigation requires a good understanding of the institutional framework in which the practice takes place.

This study is guided by an institutional theory by North (1990). North (1990) defines institutions as humanly devised constraints that structure human interaction, including formal rules (laws, regulations) and informal constraints (customs, norms cultures). The theory is applied in this study because the use of LQW in food crops irrigation is associated with health risks as such formal rules should guide its use. However, Young et al. (2008) argue that, new institutions or redesign of the existing institutions are needed to confront emerging problems. The use of low-quality water in food crops irrigation is an emerging problem in low- and middle-income countries (World Bank, 2010) as such the practice might not have been recognized in the existing institutions. It is, therefore, important to investigate the existing formal institutional framework to establish areas with gaps, convergence and divergence in relation to the use of LQW in food crops irrigation.

In Tanzania, LQW has been reported to be used in food crops production in different areas including Changarawe, Mafisa and Mazimbu areas in Morogoro Region as well as at Swaswa-Makole in Dodoma Region (Kilobe et al. 2013; Mayilla et al. 2017; Samson et al. 2018). However, the institutional framework for the use of low-quality water in food crops irrigation is not clearly known. This study assumed that the existing use of low-quality water is enabled or constrained by formal institutional framework. This study further assumed that there are formal institutions that may: (i) wholly or partially contain provisions that explicitly support or oppose the use of LQW, (ii) not clearly state whether the LQW should be used for irrigation of crops though they may highlight about procedures and rationale towards generation of LQW and (iii) lack both provisions highlighting issues related to generation and statements regarding the use of LQW. Whether one or more of the scenarios exist(s) was the puzzle the study was determined to unravel. The research findings presented in this paper provide information that can be used in strategies for realizing the achievement of the United Republic of Tanzania (URT) Vision 2025 (URT, 2010a) on food self-sufficiency and food security because most of the urban poor depend on farming as their livelihood strategy as such LQW is an important source of water for irrigation. The findings also generate the context specific information for the governance of LQW use in food crops production as recommended by WHO (2006) on water reuse.

Methodology

Scope of the study

The study was conducted in Tanzania. The analysed formal policies, legislation, and strategies were at national level, therefore representing the national scope. However, the investigation on the actual use of LQW was conducted in Changarawe Village, in Morogoro peri-urban as a case study. Changarawe village was selected to study the existing use of LQW due to the existence of the Mzumbe University WSPs whose effluent was used in various activities. Changarawe village is 25 km from Morogoro town, it lies between latitude 6°50′ and 7°0′ to the South of Equator and longitude 37°30′and 37°40′ East of Greenwich (Fig. 1).

Study approach and data collection

The study applied a mixed-methods approach meaning that it combined quantitative and qualitative research methods. Mixed approach was used for triangulation and in understanding the existing institutions and the existing uses of LQW in food crops irrigation and the views of government officials with regard to the two aspects as indicated in Fig. 2. Primary data were collected through documentary review, in-depth interviews, survey, focus group discussions and field observations.

Documentary review

Formal institutions were reviewed in the first place to understand their relevance to the use of LQW in food crops irrigation. The formal institutions reviewed were from the sectors the study considered relevant to the practice. They included National Water Policy of 2002, National Water Sector Development Strategy of 2008, Water Supply and Sanitation Act of 2009, National Agricultural Policy of 2012, National Irrigation policy of 2010, Public Health Act of 2009, National Environmental Policy of 1997, Environmental Management Act of 2004, Water Resources Management Act of 2009 and Environmental Management (water quality standards) Regulations of 2007.

In-depth interviews

The study involved a total of 17 key informants. Fifteen government officials were from the ministries (Water, Environment, Health and Agriculture), regional (Morogoro) and district levels (Mvomero and Morogoro Municipality); they were assigned to the researcher on the basis of the study objective explained in the introductory letter sent to the respective offices prior to the date of the interviews. The government officials were from agriculture, health, environment and water sectors; the sectors are relevant to the use of LQW in food crops irrigation (WHO 2006). Additionally, two key informants were officers responsible for the management of waste stabilization ponds (WSPs); one for Mzumbe University WSPs, and the other was for Mafisa area WSPs. Mafisa and Mzumbe WSPs were serving the whole Morogoro Municipal and Mzumbe University community, respectively. In-depth interviews held with key informants explored the relevance of the existing policies, legislations and regulations on the use of LQW in food crops irrigation from the practices point of view. Their views on the coordination of the practice and the existing food crops production using LQW from the WSPs were also taken on board. Checklists of questions were used to guide the interviews.

Survey, focus group discussions and field observations

A survey was undertaken with farmers to explore on the types of vegetables grown and how the LQW was distributed to farmers and other users. The survey involved a total of 30 farmers; these were all farmers using LQW from Mzumbe WSPs in food crops irrigation. Two FGDs comprising 7–8 participants were conducted. One was FGD involved a mix of male and female vegetable farmers to get their views on how LQW was used in food crops irrigation for information not well captured in the survey. Another FGD comprised a mixed sex group of farmers, brick-makers and livestock keepers to get information on the distribution of LQW for various uses. FGDs participants were selected based on sex (representation of both males and females), location of the plot (upstream or downstream the LQW canal), type of vegetables and uses of the resource (vegetable irrigation, brick-making and drinking water for livestock keepers). On the other hand, brick-makers and livestock keepers for focus group discussions were purposively selected from the list provided by the Village Chairperson and further confirmed by asking vegetable farmers. All members participated willingly in the discussions. FGDs with farmers explored on issues related to the institutional framework related to the use of LQW for food crops irrigation. A trained research assistant facilitated all the FGDs while the researcher was taking notes. Field observations by the research also complemented the data collected through survey, FGDs and in-depth interviews on the existing use of LQW from the WSPs.

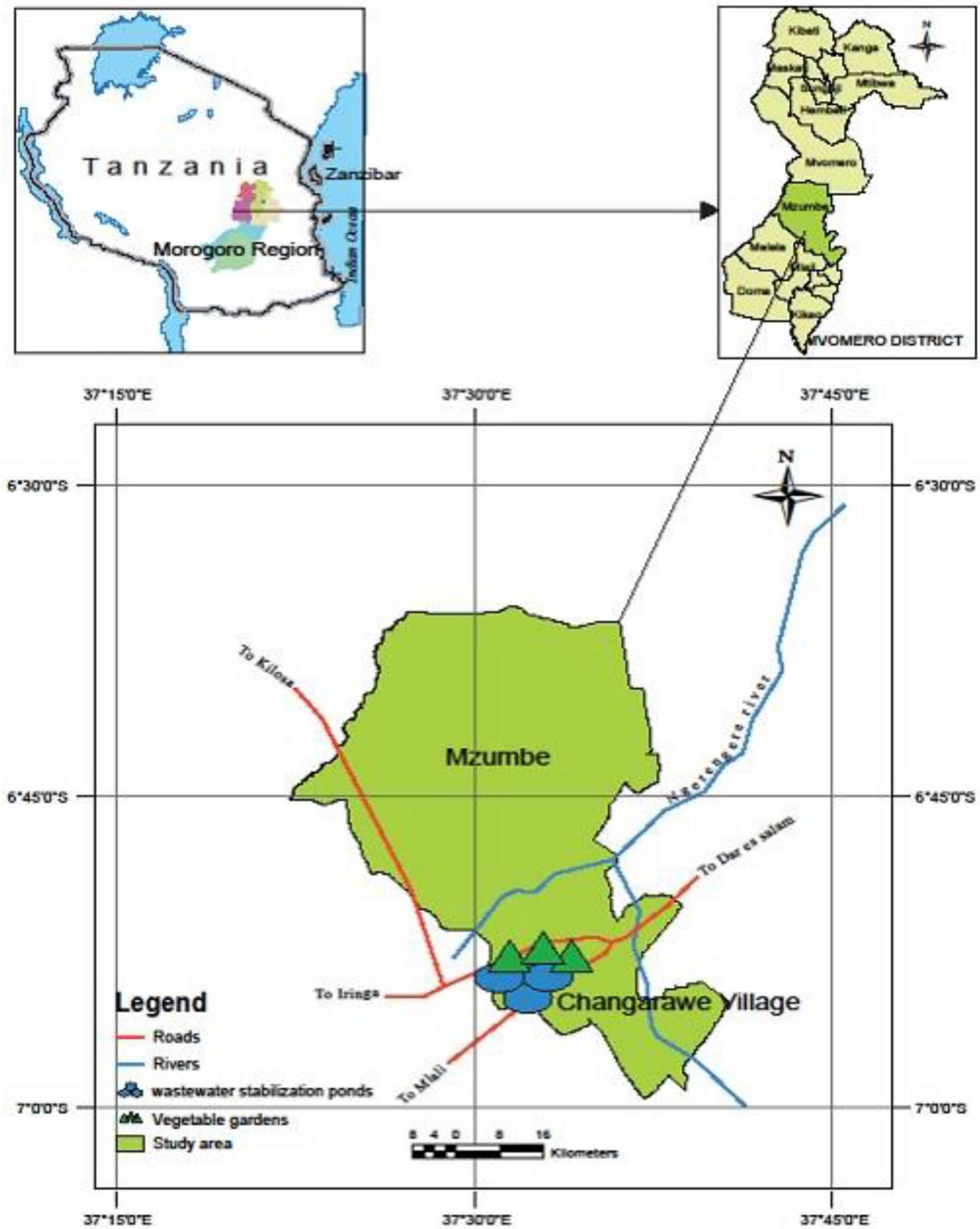

Fig. 1 Map of Mzumbe ward showing vegetables production area

Secondary data

Secondary data were obtained from various reports related to institutions for wastewater collection, treatment and effluent disposal as well as effluent quality monitoring. The reports were collected from relevant offices and/or from the internet. The main reports were from Morogoro Urban Water Supply and Sanitation Authority MORU-WASA and the Energy and Water Utilities Regulatory Authority (EWURA).

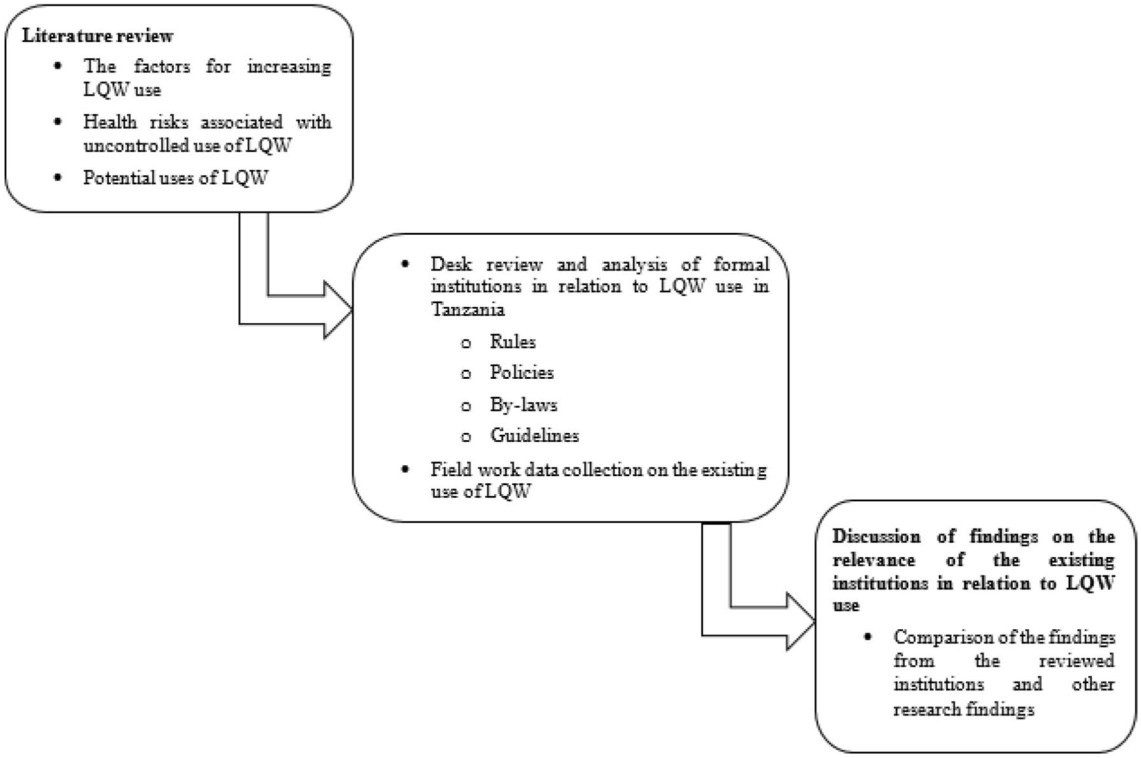

Fig. 2 Work flowchart

Data analysis

Content analysis technique was used in data analysis. Analysis of regulatory documents was done by coding the information related to the use of LQW in food crops. The coded information was organized into themes. However, qualitative data from the in-depth interviews with government officials and focus group discussions with farmers were coded based on the predetermined themes emerged from the review of formal institutions. Quantitative data from farmers' survey were analysed using Statistical Package for Social Science (IBM SPSS version 19) computer software. Results from the study were compared and contrasted with research results from other areas as indicated in Fig. 2.

Results

Four themes emerged from the review of formal institutions in relation to the use of LQW in food crops irrigation. These themes are urban farming practices, water resources management, environmental management and the presence of relevant regulatory authorities. These themes form the basis for results presentation supported with quotes from in-depth interviews, focus group discussions and the selected sections of reviewed formal institutions. The section also presents results on the existing use of LQW.

Urban farming practices

Results from documentary and in-depth interviews by government officials indicated that urban and peri-urban agriculture is a vital aspect of food security, creation of employment and supplementary source of income for the urban dwellers. According to the National Agriculture Policy (URT 2012), urban agriculture appears to be practised in open spaces where vegetable gardening is dominant over other crops grown due to limited and unsecured land. According to United Nations Urbanization Prospects (UN 2018), Tanzania is among the seven countries which are projected to contribute more than 50 million each to the urban increment between 2018 and 2050. This indicates that urban agriculture will continue to be a prominent source of livelihood to urban dwellers. Additionally, the policy acknowledges the variability of rainfall from season to season to the agriculture sector as such Sect. 4.2.1 of the policy highlights irrigation as essential for better crop production and yields. In a similar manner, the National Irrigation Policy (URT 2010b) emphasises the need for reliable sources of water for high value crops such as vegetables, flowers and fruits since they need frequent irrigation. These crops are mostly grown in urban and peri-urban areas to take advantage of the market proximity.

Documentary review of the existing institutions revealed recognition of wastewater reuse. The National Water Policy (URT 2002), pointed out water recycling where feasible should be regarded as an alternative source of water. The policy points out rapid growing population as one of the factors that affect the use of natural resources including water. The supply of potable water in urban and peri-urban areas to meet the domestic uses and irrigation farming is still limited due to low pace in water services delivery development to meet the urban population increase (URT 2002). The National Water Policy points out that, Tanzania population is projected to double in 2025, the aspect that will have a negative impact on domestic water supply services if appropriate measures are not undertaken to curb the projected scarcity. As such, water recycling should be among the means of increasing the availability of water to overcome the challenges of water scarcity emanating from population growth (Faouzi et al. 2020; Jeong et al. 2016).

Government officials interviewed acknowledged the use of LQW as an alternative source of water for irrigation in overcoming water scarcity. They were generally of the views that LQW should not be used in the irrigation of vegetables due to health risks associated with its use. Their arguments are on the basis that vegetables do not need too much cooking for nutritional requirements and some vegetables are consumed raw, as such, microbial contaminants in the LQW might expose vegetable consumers into health risks. For example, a key informant from Morogoro Regional Office stated that.

> *"crops to irrigate using this water should be cereals because they dry and are not directly consumed they go through some processing,… contrary to vegetables of which leaves are consumed whereby you find vegetables irrigated the same day of harvesting and consumption… might have bacterial contaminants…".*

Contrary to the government official's views, results from the survey with farmers indicated LQW from the WSPs was commonly used for vegetables irrigation (54.5%) followed by brick-making (32.7%) and drinking water for livestock (9.1%). Focus group discussions with farmers further revealed that, vegetables farming was good source of income to them. LQW was a sole source of irrigation water during the dry season. Jeong et al. (2016) in their study in South Korea suggested that farmers should be regarded as users of LQW while the government as the main agency for LQW use practices to provide irrigation water which meets water quality standards for reuse. The objectives of the farmers and the government are not the same; the government should control the practice for safe use of the resource.

Water resources management

The National Water Development Strategy (URT 2008) underpins the importance of water in the socio-economic development activities, such as industrial production, irrigated agriculture, livestock keeping, mineral processing, hydropower production and environmental conservation. However, water scarcity situation affects the socio-economic development activities because the erratic nature of rainfall cannot support the activities. The strategy points out that appropriate wastewater treatment is among the measures for the country to enhance access to water resources to meet the growing sectoral demands. Section 3.5.5 (a) of the strategy proposes identification of the potential for adopting particular water resource development options for different locations. Literature also indicate location specific solutions to water scarcity by pointing out urban areas as potential areas for LQW use since it is in these areas where both the population and generation of wastewater are very high (Namwata et al. 2015; Bahadir et al. 2016; Tran et al. 2016). This is because approximately 80% of urban water supply is converted into wastewater (Kurian et al. 2013).

The formal institution reviews also show the available water resources to face pollution challenges. This is due to the disposal of untreated and partially treated wastewater thus contributing to the deterioration of the quality of the water resources and exposing the public to health risks. Other studies have indicated that wastewater treatment is not only for wastewater reuse practices but also for the protection of water resources (Mukherjee et al. 2015; Andersson et al. 2016; Bahadir et al. 2016; Miller-Robbie et al. 2017; Faouzi et al. 2020). In Tanzania, National Water Resources Management Act (URT, 2009a) prohibits water pollution through waste or effluent. The Act has provisions for effluent discharge permits for ensuring pollution control. The Act mandates the Basin Water Board to provide effluent discharge permits and attach conditions to effluent discharge permits as it may deem fit. The same is reflected in Sect. 21 (1), of the National Water Supply and Sanitation Act (URT 2009b), which explains the powers and duties of Water Supply and Sanitation Authorities by stating that, "… *a water authority…shall have powers inter alia to prohibit the discharge of certain wastes into a sewerage system.*" In safeguarding the environment and health of the people, the National Water Policy (URT 2002) emphasizes on proper collection, treatment and discharge of wastewater. Additionally, Water Utilization (Control and Regulation) Amendment Act No. 10 of 1981 (URT 1981) highlights on pollution control aspects in the management of available water resources.

Results from the in-depth interviews with the government officials show that although the institutions have mentioned on the reuse of wastewater, they fall short of the strategies on how the practice can be undertaken. For example, some key informants commented that:

> "*Environmental Management Policy has mentioned the use of wastewater in agricultural production but the standards are not clearly stipulated*" (NEMC Key informant January 2015).
>
> "*The Public Health Act (2009) explains issues regarding wastewater treatment…if treatment is done well, the treated wastewater can be used for different purposes such as drinking water for livestock, irrigation… It has also mentioned the reuse of wastewater for irrigation but the Act did not cover the standards for the effluent use in irrigation*" (Morogoro Municipal key informant, March 2015).

Results from in-depth interview with Morogoro Urban Water Supply and Sanitation Authority (MORUWASA) WSPs personnel were not in a position to tell whether the LQW from the ponds is suitable for food crops irrigation or not. Additionally, in-depth interviews with Mzumbe University official responsible for the WSPs management indicated that, the University does not official permit for any use of the water from its WSPs. As the key informant stated:

> "*Previously, I was prohibiting them from the use of this water for irrigation through blocking the water channels to their farms…after receiving complaints from farmers I decided not to block the water anymore*" (Mzumbe University key informant, October 2013).

Further results from in-depth interview with the Mzumbe University personnel responsible for WSPs indicated that, effluent from the WSPs on its way to the tributary as a reservoir passes across local people's farms, the situation that gave farmers a degree of rights to use the LQW for vegetables irrigation and other uses.

Environmental management

Closely related to the results presented in Sect. 3.2 above, documentary review also indicates that Tanzania has institutions in place for managing its environment. The National Environmental Standards Committee of the Tanzania Bureau of Standards is among the institutions. The Committee is responsible for setting minimum quality standards for sewerage as stipulated under Sect. 4(1) of the Environmental Management Water Quality Standards Regulations (URT 2007). It also prescribes requirements for the operator of any effluent treatment plant, the minimum quality standards for the treatment of effluent before their final discharge into public sewer systems or into any body of water. The committee also establishes minimum quality standards for different uses of water including irrigation uses. Additionally, the national environment management regulations (URT, 2007) have explained clearly on the nature of the wastewater to be discharged into the sewerage system. The first schedule in the Amendment Act No. 10 of 1981 also provides the quality standards of effluents before disposal to the environment. Another institution is the Tanzania Bureau of Standards (URT 2005) which provides permissible effluent quality standards, based on environmental management.

However, Sect. 81(b) of National Public Health Act (URT 2009c) states that, the Authority shall ensure that the sewage is appropriately treated and prior to its discharge into water bodies or open land, such that the sewage will not increase the risk of infections or ecological disturbance and environmental degradation. The Act also mentions about making by-laws prescribing appropriate penalties to control the spread of diseases and infections by punishing indiscriminate disposal of human excreta wastes. Section 101 (2) states that "… a person shall not be permitted to (a) discharge directly or indirectly into any public sewer (i) any matter from a manufacturing process or a factory, other than domestic sewage or storm water, except by a written agreement with the Authority; (ii) any matter which is prohibited under this Act or any other written law". This separation of wastewater helps in designing appropriate treatment measures since wastewater, from industries contains chemicals that can have negative impact on human health (Shomar and Dare, 2015). According to Grisolia et al.; (2005) and Thewes et al. (2011) area where no separation of wastewater occurs, the wastewater generated contain numerous pollutants from domestic and industrial sources as such LQW (treated wastewater) may contain complex mixture of organic and inorganic compounds that may not be degraded.

Environment management regulations (URT, 2007) also highlight various offences and their penalties for example offences on the disposal of hazardous substances. Regulations under Sect. 29 state that "a Basin Water Officer or an Environmental Inspector who observes or receives information on discharge of a contamination into the environment in an amount, a concentration or manner that constitutes a risk to human health or environment, may serve an emergency prevention order". The Regulations also specify the permissible limits for municipal and industrial effluents, sampling frequency and sampling location.

Results indicate the presence of national quality standards for effluent although the effluent is not officially declared for reuse. However, Faouzi et al.(2020) in the study conducted in Morocco found the effluent quality standards to be similar to the national standard for irrigation water. This implies that, setting and adhering to effluent quality standards for environmental management contributes to the use of LQW in irrigation.

Regulatory authorities

Findings from the review of formal institutions show that the National Environmental Management Act (URT 2004) considers wastewater disposal as a matter of concern in the protection of human health and the environment. The Environmental management sector through the National Environmental Management Council (NEMC) has the mandate to ensure the overall management of the environment. NEMC was established to undertake enforcement, compliance, review and monitoring of environmental impact assessment (EIA) for various activities. In collaboration with relevant sector ministries, NEMC enforces and ensures compliance with the national environmental quality standards. With regard to the use of LQW in food crops irrigation, the review further indicated the presence of regulatory authorities responsible for ensuring safe disposal of effluents. Urban Water supply and Sanitation Authorities (UWSAs) and Local Government Authorities (LGAs) are responsible for Sewerage services and on-site sanitation services respectively. The UWSAs are under the Ministry of Water and LGAs are under Prime Minister's Office, Regional and Local Government Authorities. Additionally, Energy and Water Utilities Regulatory Authority (EWURA) was established under the EWURA Act (URT 2001) is overseer of regulation of water supply and sewerage services. It is the one licensing the UWSAs to operate in accordance with the Water Supply and Sanitation Act (URT, 2009b).

Water Utilization (Control and Regulation) Act No. 42 of 1974, through its Amendments Act No.10 of 1981 stipulates pollution control aspects as well as decentralisation of water resources management to the lowest appropriate level. Regarding the disposal of effluent from WSPs to the environment, the UWSAs are required to have discharge permits offered by the Basin Water Board (URT 2009c). The discharge permits are offered based on the criteria if the effluent meets the required minimum quality standards. Each water utility has an obligation of testing and monitoring effluent against the maximum permissible concentrations of various substances stated under Sect. 8: 18b of the Water Utilization (Control and Regulation), Amendment Act No. 10 of 1981 (URT1981). For example, the maximum permissible limit for total coliform organisms in the effluent before disposal to the aquatic environment is 10000 counts/100 ml and that of 5-day Biochemical Oxygen Demand (BOD5) is 30 mg/l (URT 2005; 2007). The major aim for this limit is to determine the effluent quality as it is released into the environment and on checking the operational efficiency of the wastewater treatment systems. Additionally, The National Water and Sanitation Act (URT 2009b) also requires Energy and Water Utilities Regulatory Authority (EWURA) to monitor water quality standards of performance for the provision of sanitation services by UWSAs. Each water utility has an obligation of testing and monitoring effluent quality within the set standards for different parameters. The environmental management sector and water basin authorities mandate is to ensure the effluent is environmentally safe whereas EWURA is in place for monitoring the compliance with the standards required for the disposal.

Despite the existence of regulatory authorities for quality standards compliance**,** in-depth interviews results indicated limited effluent quality compliance monitoring. The authorities responsible for compliance monitoring are not undertaking the effluent quality assessments as two of the interviewed government officials explained hereunder:

> "*We are the regulators of the community and the government agencies. The government agencies are responsible for the treatment of wastewater. Wastewater has to be treated such that when discharged to the environment has to be of the quality required. The agencies such as the waste stabilisation ponds owners are supposed to do daily monitoring of the effluent and NEMC is supposed to conduct quality assessment of the waste stabilisation ponds effluent after every 6 months. But this is normally not done both at the agency level and NEMC due to lack of human and financial resources*" (NEMC key informant, January 2015).
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> "*There is no proper management that you can rely on…it can reach a point when the personnel responsible for quality monitoring request for chemicals for samples testing without success ...*" (Morogoro Municipal key informant, March 2015).

Existing uses of LQW

The results from farmers' survey indicated LQW from the WSPs was commonly used for vegetables irrigation (54.5%) followed by brick-making (32.7%) and drinking water for livestock (9.1%). Results from farmers' survey indicated that, vegetable production in Changarawe village was undertaken during dry seasons mainly from June to October. Vegetables produced were amaranths, sweet potato leaves, Chinese cabbages, African egg plants and tomatoes. Vegetables were grown in small plots ranging from 200 m^2 to 1000 m^2 with amaranths and tomatoes being grown in relatively smaller and bigger plots, respectively. Amaranths had a relative short maturation period (21 days) allowing more growing cycles[1] per season[2] while sweet potato leaves allowed continuous picking over a prolonged period of time, a maximum of two years.

[1] Duration from sowing to harvesting.

[2] Vegetables growing period (June-October).

Investigation on how LQW was utilized among the three activities indicated the use of informal distribution arrangements (scheduling) based on the nature of activities. Since vegetables irrigation was conducted during day times, water was scheduled to farmers during that particular time. Low-quality water access for vegetables irrigation was based on 'first come, first served' approach. It was like a snowballing kind of, and this was done daily. The first farmer to access the water early in the morning passed on the water to the farmer who came next to him/her and so on. On the other hand, brick-makers collected LQW through the hand-dug wells during the night to have enough water for brick-making during the day time as such vegetables irrigation activities by farmers were not interfered.

Results from FGDs further show that vegetables utilised relatively higher amount of LQW than brick-making. One FGD participant contended that "Vegetables irrigation utilise a lot of water. During very hot days; irrigation is done twice; during morning and evening." (Male vegetable farmer, Changarawe village). However, the findings from the FGDs further indicated that brick-making was mainly conducted for three months (July, August and September). Burning of bricks was undertaken before the start of short rains in October so that bricks are not destroyed by rain as one of the brick-makers explained during the FGDs "…we are making muddy bricks, we need to burn them before rain…"(Brick-maker in Changarawe village, June 2015). It was noted during the focus group discussion that livestock were also not supposed to drink water from the hand-dug wells meant for brick-making and vegetable irrigation water to avoid the destruction of both vegetables and bricks. Livestock accessed water from the canal in between the WSPs and the vegetables plots while on their way to and/or from grazing areas.

Despite all these uses, interview with the personnel revealed limited cleaning of an earth canal and WSPs. Neither the Mzumbe University nor the LQW users cleaned the canal. Vegetation was seen growing along the LQW canal. The limited cleaning of the WSPs by the Mzumbe University was also observed during data collection; water hyacinths were observed in the ponds. This was further revealed during the in-depth interview with Mzumbe University official (a key informant); the removal of water hyacinths was conducted at least once per year depending on financial resources availability. The key informant also stated that he had never observed the removal of sludge from the WSPs since he was employed by the University (the institute by then) in 1995.

Discussion

The findings have indicated that, Tanzania has no specific formal institutions governing the use of LQW with no declaration as to whether LQW is suitable for food crops irrigation. However, the study has found, the use of LQW can be well linked to urban agriculture, water resources management and environmental management. Urban and peri-urban agriculture have been pointed out to contribute to employment creation and food security. Urban agriculture takes an advantage of open spaces to grow vegetables production, which takes short time to mature. It is in the urban and peri-urban areas where the vegetables are consumed the most; hence its production needs to be within these areas and their proximity (Kalavrouziotis et al. 2011; Kopiyawattage et al. 2019). Vegetable production cannot be sustained with poor potable water supply that is experienced in most urban areas of the developing countries like Tanzania (Woltersdorf et al. 2015) while the drought intolerant vegetables require water every day (Weldesilassie et al. 2011). The contention by the formal institutions that "…*wastewater recycling where feasible should be considered as a means of increasing availability of water resources in overcoming the challenges of water scarcity*" fits well with urban and peri-urban farming because it is in these areas where the resource is generated most and clean water has competing uses creating a need for other alternative sources of water to support irrigation farming (Namwata et al. 2015; Bahadir et al. 2016; Tran et al. 2016).. This study argues that LQW generated from WSPs can ensure year-round supply of water for vegetables irrigation activities.

In the absence of clear information on whether or not to use LQW in vegetables irrigation, farmers always choose to use the resource, especially when no other alternative sources of water are available to them (Weckenbrock et al. 2011; Namwata et al. 2015; Bahadir et al. 2016; Helmecke et al. 2020). Water scarcity and lack of choice are reported as the first motivation for farmers to use LQW in irrigation. Farmers in other areas have been reported to have used their own initiatives to divert untreated wastewater to their farms and fight for the rights to use that resource (Weckenbrock et al.; 2011). Prohibiting the community members from the use of the resource without providing them with alternative solutions has been reported to cause disgust (Mahonge 2010, 2012). Also, Jiménez et al. (2010) concluded that recommendations for prohibiting the use of LQW in agricultural production are nearly impossible to implement in most developing countries because of economic and social reasons.

The National Water Policy and strategy for water resources development acknowledge the impact of increased population on water availability. Appropriate wastewater treatment and wastewater recycling have been repeatedly mentioned in the reviewed institutions as measures for increasing water resources availability. LQW generated from the WSP is a potential alternative source of water in urban and peri-urban areas. Waste stabilisation ponds as wastewater treatment facilities are characterised as low-cost mechanisms of providing effective and sustainable way of treating wastewater suitable in developing countries where limited financial resources are most experienced (Scheierling et al. 2011; Rahmatiyar et al. 2014). The findings from this study have indicated that farmers are using effluent from the last stabilization pond while LQW flows to the reservoir for disposal. This means that farmers are using treated domestic wastewater for irrigation of the vegetables and other uses. Research from elsewhere has indicated that well treated domestic wastewater has low health risks compared to wastewater generated from industries (Weckenbrock et al. 2011). Additionally, the nature of wastewater and the treatment method used determine the quality of the treated wastewater and its ultimate end use. Understanding the composition of wastewater is very important aspect in the safe use of LQW in food crops irrigation (Jeong et al. 2016). In Tanzania, there are authorities for the control of wastewater disposal into the WSPs. If the authorities are keen in undertaking compliance monitoring, the LQW from the WSP should be that from domestic uses that is reported to be suitable for food crops irrigation.

Additionally, the findings indicate the presence of regulatory authorities (actors) responsible for effluent quality compliance monitoring before its disposal, a crucial aspect in the safe use of LQW in food crops irrigation. Other research findings (Samson et. al. 2017) indicated limited effluent quality monitoring. The authors found that MORUWASA as the water supply and sanitation authority had no laboratories for effluent quality assessment; the assessment is done in Dar es Salaam which is 200 Kms away, the aspect which hinders regular monitoring of the effluent as per WHO (2006) guidelines. Research elsewhere indicates that the effectiveness of the quality standards depends on its enforcement, which in turn depends on the political will (Horan, 2003). Regulations that need frequent monitoring are often seen as being too expensive to enforce. Most of the developing countries have limited environmental management agencies which are concurrently poorly funded and without real political support (Horan, 2003). Since the ultimate objective of permissible limits for effluents discharge is environmental and public health protection, we argue that, compliance with these limits contributes to the safe use of LQW in food crops irrigation. The presence of regulatory authorities to ensure that the effluent is environmentally safe and for monitoring the compliance with the standards required for the disposal indicates the availability of institutional structures that can be strengthened for LQW use in food crops irrigation. This is because WHO (2006) recommends regular monitoring of the effluent quality to safeguard the public health, the function which could be carried out by the authorities (UWSAs). If well managed, LQW from WSPs is a potential source of safe water for food crops irrigation (Rahmatiyar et al. 2014; Faouzi et al. 2020). Nevertheless, negative views by the government officials on the use of LQW in food crops irrigation should not be ignored. The use of the resource is associated with health risks if appropriate measures are not in place (WHO 2006). Acknowledgement of water scarcity and recognition of LQW as an alternative source of water found in the reviewed institutions is of limited importance if there is lack of coordination among the sectors on how the resource can be safely utilized.

Policy implications

The use of LQW in food crops irrigation is internationally recognised and promoted due to increasing water scarcity and WHO (2006) guidelines provide benchmarks for the development of country specific guidelines. The findings have indicated appropriate wastewater treatment and wastewater recycling as potential strategies towards increasing water availability. Besides, the formal institutions reviewed regard water as an important resource in achieving the national development objectives stipulated in the Tanzania Development Vision 2025. Water is the main driver for the achievement of sector-based development objectives, so its management requires deliberate efforts. The existing institutional framework regard integrated water resources management as a means towards the sustainable management of water resources whereby each sector has a stake in its management. Low-quality water use in food crops irrigation contributes towards the integrated water resources management in achieving more than one inter-related objectives. If LQW use in food crops irrigation in urban and peri-urban areas is well managed, it can contribute to food and income security as well as creation of employment opportunities. The institutions reviewed show the water reuse as an alternative source of water. The presence of authorities for water and effluent quality standards as well as quality standards compliance monitoring provides opportunities for safe use of LQW in food crops irrigation. The only gap found is the lack of official recognition LQW as the alternative source of water for food crops irrigation, the situation that might have contributed to worries by the government interviewed. The institutions and the regulatory authorities are not oriented towards the use of LQW in irrigation. The study argues that lack of formal institutions to ensure safe use of LQW impinges the use of the resource in urban and peri-urban areas where it is generated the most. The existing informal use of LQW in food crops irrigation because of water scarcity pressure indicates that Tanzania is behind the pace in the formulation of guidelines for the practice. According to WHO (2006), institutions are the basis of governance. This study has generated knowledge on the current institutional framework which is helpful in decision making on whether to formulate new institutions or adapt the existing ones so that use of LQW in food crops irrigation is formally recognised and regulated.

Conclusions

Wastewater treatment and/or recycling have been pointed out in the institutions reviewed as the measures for increasing water resources availability in response to water scarcity challenges. However, the institutions are silent on how LQW can be used as an alternative source of water; existing institutions have not provided clear statements to support or oppose the use of LQW (treated wastewater) in food crops irrigation. The study concludes that the institutional framework for the use of low-quality water in food crops irrigation is not clearly known. There are formal institutions that contain provisions for the possibilities of LQW use, however, there is no specific institutions for LWQ use in food crops irrigation. Therefore, the current use is still informal as such the health of both farmers and consumers might be at risk. Existing institutions have emphasized on appropriate wastewater treatment and its rationale on health and environment protection, the aspects that have positive contribution to the use of LQW in food crops irrigation. The presence of specific institutions on the separation and domestic wastewater and industrial wastewater together with the set effluent quality standards show that the country is in a good position if it has to formalize the use of LQW in food crops irrigation.

Lack of clear formal institutions to support or oppose the practice has created institution vacuum. The study conforms to the arguments by North (1990) that when formal institutions are weak, informal institutions play a larger role in structuring human interactions in situations where there is a pressing issue. This study has indicated that the existing institutions acknowledge water scarcity and recognise LQW as a potential source of water. It is water scarcity that forced people to utilize LQW for irrigation, brick-making and drinking water for livestock. Nevertheless, the existing uses are informal, based on the positive benefits such as plant nutrient in the water, year-round availability, easy accessibility and free of charge (Samson et al. 2018) viewed by farmers while ignoring the negative effects such as health risks to resource users and consumers of the products (especially food crops). The study is of the view that, lack of formal recognition of the practice limits safe use of LQW. It is better for the institutions to explicitly state whether the resource is allowed or not allowed for use. For either decision, the two concerns pointed by Jiménez et al. (2010) for the use of LQW should be considered; public health challenges and prohibition of farmers from use of the only irrigation water source available to them. Therefore, the study recommends formulation of new institutions or review of the existing ones to accommodate use of LQW in food crops irrigation to take advantage of the productive uses of the resource while protecting the health of the public. This is because water scarcity will continue to be a challenge due to climatic variations and rapid population increase. The formal institutional framework should clearly stipulate the roles and responsibilities of the sewerage services operators and regulators in relation to the use of LQW in food crops irrigation. Roles and responsibilities among the ministries and authorities in relation to LQW irrigation should be clearly stated in these institutions. A clear link for multi-sectoral collaboration towards safe use of LQW for food crops irrigation should also be provided.

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Data availability Data and materials are available upon request.

Declarations

Conflict of interest The authors have no conflict of interest.

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