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***Research Paper***

# Urban Wastewater Utilization for Economic Activities in Dodoma Urban District, Tanzania

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***Abstract:*** *In the semi-arid areas of Tanzania that experience frequent periods of drought, wastewater is a critical resource for landed and landless households. This wastewater, which is generated daily by a rapidly growing population, and which flows into the ground, supports a variety of livelihood activities that require water. This study was conducted among 215 randomly and purposively sampled respondents to assess the use of wastewater for economic activities for improving livelihood in Dodoma Municipality which is one semi-arid areas in Tanzania. Specifically, the study intended to (i) identify the economic activities practised, (ii) determine the main economic activities that utilize wastewater and, (iii) find out the extent of wastewater utilization for economic activities in the study area. Primary data were collected through a survey among wastewater users and semi-structured interviews with key informants. Secondary data were collected through documentary review of different documents obtained from the relevant offices and officials. Descriptive statistics including cross tabulation and frequency distributions were analysed. The findings show that the major economic activities that utilize wastewater are farming (48%), livestock keeping (41%), brick- making (32%) and fishing (9%). The majority of respondents used wastewater resource for gardening, mainly tomatoes (26 %), followed by green vegetables (18%), okra (18%) and cowpeas (17%). With regard to livestock keeping, the majority of respondents used wastewater for rearing cattle (42%), goats (32%) and pigs (10%). Despite the existing economic activities that utilize wastewater, wastewater is generally underutilized in the study area. Therefore, policy makers and other stakeholders should ensure full utilization of wastewater potentials including, construction of livestock watering areas, fishing ponds, dips and irrigation structures.*

**Keywords:** Livelihood activities, semi-arid areas, wastewater utilization, Tanzania.



## Introduction

Urban wastewater resource can support a wide variety of livelihood activities that require water. Different people make use of urban wastewater for economic activities especially those related to agriculture, aquaculture, horticulture and floriculture [19, 24]. Raschid-Sally and Jayakod (2008) estimate that about 74 percent of the 53 cities in developing countries use wastewater for agriculture. Wastewater use in urban and peri-urban agriculture helps to promote irrigation farming. This is due to the fact that wastewater is a reliable source, both in terms of availability and volume in promoting irrigation systems compared to rain or freshwater supply [1, 15].

WHO (2000) shows that wastewater is used for crop production, which includes fodder grasses, vegetables, cereals, ornamental plants, trees and flowers, timber crops and fruit trees as well as for aquaculture and is often the only source of irrigation in urban areas. In fact, the importance of wastewater has not only been acknowledged by farmers, but also by livestock keepers as a potential source of fodder during the dry and rain seasons [4]. Fishing is another important economic activity practised in wastewater wetlands [4, 7]. Similarly, many people in developing countries have been using wastewater for bricks making partly because mud bricks are inexpensive and efficient

building materials used worldwide to make fireproof buildings and low-cost homes [11]. Other reported uses of wastewater include underground water conservation which ensures reliability of water supply, low-cost method for sanitary disposal of municipal wastewater and increases in crop yields [13, 24]. Wastewater is, therefore, an alternative resource for livelihood activities in many urban and peri-urban areas which determine direct access to food, income and employment opportunities [10, 13].

In Tanzania, it is estimated that 80 percent of the effluents are discharged on land or in water bodies. In urban areas, big volumes (greater than 41,703,016 $m^3$) of wastewater are biologically treated annually. However, only 33 percent of this amount, which is equivalent to 13,761,995 $m^3$ is used for economic activities [20]. Despite the big volumes of wastewater being discharged in the urban areas of Tanzania, few economic activities such as agriculture, aquaculture and floriculture are undertaken in wastewater wetlands. Further, little information on its potential in terms of supporting economic activities is known. Most of the previous studies on wastewater have tended to focus on the impact of wastewater use for animals, plants and human beings [6, 9, 14, 19]. Thus, the potential utilization of wastewater for livelihood activities has received less attention in the academic literature.

Against this background, this study examines the use of wastewater for economic activities in urban and peri-urban areas in Tanzania using Dodoma Municipality as a case. Specifically, the study intended to (i) identify the economic activities practised in the study area, (ii) determine the main economic activities that utilize wastewater, and (iii) find out the extent of wastewater utilization for economic activities. The paper contributes to the scant empirical literature on wastewater utilization in Tanzania by focusing on the importance of wastewater for economic activities so as to promote sustainable utilization of wastewater for reducing households' income poverty in semi-arid areas of Tanzania.

The paper draws on the theory of wastewater utilization, which asserts that rapid population growth in many municipalities in the arid and semiarid parts of the world continues to place increasing demands on limited fresh water supplies. Population growth has not only increased the demand for fresh water but also increased the volume of wastewater produced. Treated or recycled wastewater appears to be the only water resource that is increasing as other sources are dwindling [18, 24]. Thus, use of wastewater for irrigating landscapes is often viewed as one of the approaches to maximize the utilization of the existing water resource and stretch current urban water supplies [24]. Consequently, many farmers, especially those in urban areas, use wastewater because it is free of charge and abundant, even during droughts, and is full of nitrates and phosphates, that act as effective fertilizers [24]. This paper addresses the question of whether this theoretical understanding applies to the study area.

## Material and Methods

### Description of the study area

The present paper is based on an empirical study that was carried in Dodoma Urban district in central Tanzania. As already stated, the specific objectives of the study were to (i) identify the economic activities practised in the study area, (ii) determine the main economic activities that utilize wastewater, and (iii) find out the extent of wastewater utilization for economic activities. Dodoma Urban district is located 486 kilometres East of Dar-es-Salaam and 441 kilometres South of Arusha, the headquarters of the East African Community. Dodoma region lies between $4^o$ and $7^o$ latitude South and between $35^o$ and $37^o$ longitude East. It covers an area of 2,669 square kilometres of which 625 square kilometres are urbanized. According to the 2012 National Population and Housing Census, Dodoma Urban District has a total population of 410, 956[22]. The present study was conducted in Swaswa settlement, which is found in Makole ward. Swaswa settlement is located in the North East of Mlimwa Hill, about six kilometres from the main town centre of Dodoma Municipality, the Capital of Tanzania. The area has four *mitaa* which are Swaswa Bwawani, North, Mbuyuni and Uheheni. The area has Waste Stabilization Ponds (WSPs) which provide wastewater for economic activities of the surrounding community, which is the main focus of this study.

### Research design

A cross-sectional design using a case study was used as a research design [2]. The type of research conducted was a case study research. This is characterised by the ability to obtain detailed information on a single case. Thus, the study was conducted in Dodoma Urban District which has similar conditions with other semi-arid areas, including similar sources of water and discharging processes of wastewater. Data were collected at a single point in time, which is one of the characteristics of a cross-sectional design. The design was chosen due to the fact that economic activities conducted in the study area are not expected to change within short period of time and, hence, could provide valid and reliable data. The target population of the study was wastewater users in the urban area. The sampling frame of the study was a list of household heads of wastewater users and key informants from Dodoma urban district. The list of household heads of wastewater users and key informants was obtained from the Ward Executive Office and respective offices.

**Sampling procedures and sample size**

The study employed both purposive and non-purposive sampling techniques. Purposively, out of the 7 districts (Kondoa, Mpwapwa, Chamwino, Dodoma Urban, Bahi and Chemba Districts), Dodoma Urban district was selected. The criteria for selecting the district were wastewater availability and its collection in WSPs. The second stage also involved purposive sampling technique by selecting Makole ward from the district. The ward was selected because it is the area for discharging urban wastewater. The next stage involved selection of 7 key informants purposively. These were Mtaa Executive Officer (MEO), Ward Executive Officer (WEO), District Agricultural and Livestock Development Officers (DALDO), Wastewater Engineers (WWE), District Health Officers (DHO), Councilors, District Planning Officers (DPLO), Capital Development Authority Officer (CDAO). The key informants were selected based on their knowledge of wastewater, authoritative power to influence wastewater use and duration they have stayed in Swaswa settlement area. Stratified sampling technique was also used to select wastewater users from the three *mitaa* in the ward namely Swaswa Bwawani (SB), Swaswa North (SN) and Swaswa Mbuyuni (SM). This was followed by simple random sampling of 68 respondents from each *mtaa* making a total of 204 respondents. This technique was used because of its simplicity, low degree of sampling error and ability to provide equal opportunity for all respondents being included in the sample [17]. An equal number of respondents was selected from each location because the population does not differ much in most of the socio-economic activities.

**Data collection methods**

This study used mixed methods of data collection from multiple sources of evidence. The decision to use a combination of data collection methods was dictated by the diversity of information needed to achieve the study objectives. This is because there were some specific data that could not be collected by single method. Primary data were collected through a questionnaire survey, semi-structured interviews, focus group discussions (FGDs) and observation. The questionnaire consisted of both open and closed-ended questions. In-depth interviews were conducted with key informants using checklists. In-depth interviews were chosen as important methods of data collection partly due to their flexibility in obtaining information from various actors and their ability to capture additional information that was useful in interpreting the results of the sampled respondents [3].

One mixed FGD was conducted with 10 participants: WEO (1), MEO (1), mtaa representatives (6), and influential people (2). These respondents were selected to participate in the FGD because they are familiar with the wastewater activities practiced in the study area. Therefore, they were expected to provide information which could not be provided by other respondents.The information gathered using this technique was used to complement and counter check information obtained through the survey and semi-structured interviews. In addition, the researcher acted as external observer. Ad hock visits were done to avoid participant behavior change during field visit. While notebooks were used as a tool for recording important information from sampled respondents and key informants, digital camera was used to take pictures of vital events in the study area. Secondary data were collected through documentary review of sources including: books, reports related to wastewater utilization, journals (published and unpublished) and websites.

In order to avoid errors, data were cross checked before analysis. This was done to check how data behave in each variable and to note the missing information. This cleaning process was done by SPSS through running frequencies. Thereafter, the cleaned data were analysed using SPSS and Microsoft Excel software packages. Descriptive statistics including means, frequencies, percentages and cross tabulation were computed for most of the survey variables.

**Results and Discussion**

**Major economic activities practiced in the study area**

The study findings show that the common economic activities practiced by respondents in the study area are farming (31.6%), petty business (21.0%), livestock keeping (19.5%), salaried employment (9.8%), brick-making (9.2%) and fishing (8.9%) (Table 1). Except for petty business and salaried employment which do not directly depend on wastewater, the rest of these activities depend on wastewater. This means that wastewater is an important resource for most of the economic activities practiced in Swaswa settlement area.

**Major economic activities that utilize wastewater in the study area**

Further analysis was performed to examine economic activities that utilize wastewater resource in the study area.

Farming (48.0%) by far seemed to be the major economic activity which utilizes wastewater in all three locations (Figure 1). This was further supported by the findings of the FGD, which revealed that farming is mostly practiced at Swaswa area because there is reliable wastewater for irrigation, cheap land for cultivation, adequate nutrients from wastewater and cheap labor. Farmers use wastewater throughout the year to grow different crops in the rainy season, and vegetables in the dry season. In addition,

wastewater irrigation is also practised during the rainy season to support rain fed farming partly due to unreliable rainfall.

**Table 1: Major economic activities practiced by respondents by location**

| Variable | Respondents (%) | | | Total Sample n=204 |
|---|---|---|---|---|
| | Location of respondents | | | |
| | SB(n=68) | SN(n=68) | SMB(n=68) | |
| Farming | | | | |
| Within Swaswa | 93.0 | 94.7 | 93.6 | 93.8 |
| Outside Swaswa | 7.0 | 5.3 | 6.4 | 6.2 |
| Overall percent | 30.8 | 32.9 | 28.7 | 31.6 |
| Bricks making | | | | |
| Within Swaswa | 100.0 | 100.0 | 100.0 | 100.0 |
| Outside Swaswa | 0.0 | 0.0 | 0.0 | 0.0 |
| Overall percent | 10.8 | 7.5 | 8.5 | 9.2 |
| Petty business | | | | |
| Within Swaswa | 82.9 | 57.5 | 81.2 | 72.9 |
| Outside Swaswa | 17.1 | 42.5 | 18.8 | 27.1 |
| Overall percent | 18.9 | 23.1 | 21.2 | 21.0 |
| Grass cutting and selling | | | | |
| Within Swaswa | 74.4 | 63.3 | 73.3 | 70.7 |
| Outside Swaswa | 25.6 | 36.7 | 26.7 | 29.3 |
| Overall percent | 21.1 | 17.3 | 19.9 | 19.5 |
| Livestock keeping | | | | |
| Within Swaswa | 100.0 | 100.0 | 100.0 | 100.0 |
| Outside Swaswa | 0.0 | 0.0 | 0.0 | 0.0 |
| Overall percent | 0.7 | 10.5 | 9.3 | 9.8 |
| Fishing | | | | |
| Within Swaswa | 100.0 | 100.0 | 92.9 | 97.8 |
| Outside Swaswa | Nil | Nil | 7.1 | 2.2 |
| Overall percent | 8.7 | 8.7 | 9.3 | 8.9 |

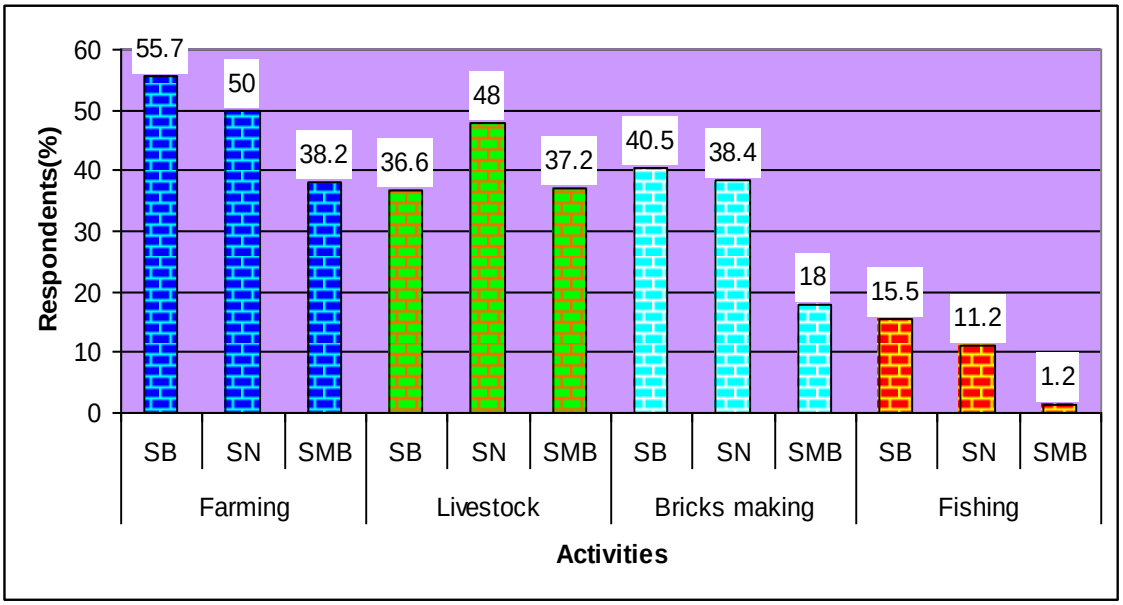


**Figure 1: Proportion of sample respondents involved in wastewater related activities**

The results in Table 2 indicate that over one-quarter of the respondents used wastewater resource for irrigating tomatoes (26.2%). This was followed by green vegetables, okra and cowpeas which accounted for

17.6%, 17.5% and 16.7%, respectively. However, there were variations in the proportions of respondents who practiced wastewater irrigation farming for specific crops across the locations. For instance, tomatoes and green vegetables production ranked the first in terms of using wastewater resource among respondents at Swaswa Bwawani. A similar pattern was also noted for okra and green paper for the respondents at Swaswa North. This is because the area is suitable for crop production, especially those mentioned above.

These results are in line with the findings by Buechler and Gayathri (2003) who reported that the predominant wastewater crop in Vietnam is rice, grown on 76 percent of the areas in the spring and 85 percent in the summer seasons. Other crops grown in summer seasons were green vegetables, amaranthus spp, coriander, hibiscus, sorrel, potatoes, tomatoes, eggplants, ladyfinger (okra), banana and jasmine. In Tanzania, irrigation has been advocated as a reliable source for promoting production and productivity of both cash and food crops [21].

However, the emphasis has been mainly on other sources of water for irrigation, but less on wastewater. Thus, the findings of this study provide evidence to show that wastewater is an important resource of water for irrigation that has remained underutilized in many parts of the country, including in the study area.

The findings further show that substantial proportions of the respondents (40.6%) in all three locations practiced livestock keeping as an economic activity for improving their livelihood (Figure 1). Swaswa North had the highest percentage of livestock keepers (48%) compared to the other *mitaa.* During the field work, domestic animals such as cattle, goats and sheep were found drinking wastewater in ponds as shown in Plate 1. Normally, the livestock keepers watered their livestock in the ponds especially during the dry season when there was critical shortage of reliable sources of water. In this case, the ponds did not only benefit the Swaswa community alone, but also the neighbouring communities of Miyuji, Mpamaa and Nzuguni.

**Table 2: Types of farming practised by sample respondents by crops**

| Type of Farming | Crop Grown | Respondents % | | | Total Sample n=204 |
|---|---|---|---|---|---|
| | | Study location | | | |
| | | SB(=68) | SN(n=68) | SMB (n=68) | |
| Irrigation | Green peppers | 14.6 | 15.5 | 14.8 | 15.0 |
| | Tomatoes | 25.0 | 25.1 | 28.9 | 26.2 |
| | Green vegetables | 18.2 | 17.2 | 17.5 | 17.6 |
| | Cowpeas | 17.9 | 17.2 | 14.7 | 16.7 |
| | Okra | 17.2 | 17.8 | 17.5 | 17.5 |
| | Egg plants | 7.1 | 7.2 | 6.6 | 7.0 |
| Rain-fed supported | Pigeon peas | 14.6 | 18.5 | 27.5 | 20.0 |
| | Rice | 61.8 | 60.5 | 53.7 | 58.8 |
| | Maize | 13.5 | 12.4 | 10.0 | 12.0 |
| | Sweet potatoes | 10.1 | 8.6 | 8.8 | 9.2 |

**Plate 1: Domestic animals watered in Swaswa Waste Stabilization Ponds**

The majority of respondents used wastewater for rearing cattle (41.8%). Goats and pigs ranked second and third in terms of utilizing wastewater accounting for 32.2% and 10.1%, respectively. Very few respondents reported the use of wastewater for rearing chicken and ducks, which accounted for only 3.4% and 3.8%, respectively (Table 3).

Experience from other developing countries such as Andhra Pradesh-India and China shows that wastewater resource is useful for livestock in terms of providing fodder and drinking water. Hence, it contributes to increasing milk production, meat and other animal products [8, 12].

**Table 3: Types of livestock that utilize wastewater resource at Swaswa**

| Types of livestock | Respondents (%) | | | Total n=204 |
|---|---|---|---|---|
| | Location of respondents | | | |
| | SB(n=68) | SN(n=68) | SM(n=68) | |
| Pigs | 08.1 | 08.3 | 16.0 | 10.1 |
| Cattle | 41.9 | 43.1 | 40.0 | 41.8 |
| Goats | 33.7 | 33.3 | 28.0 | 32.2 |
| Sheep | 9.3 | 11.1 | 4.0 | 8.7 |
| Chicken | 2.3 | 4.2 | 4.0 | 3.4 |
| Duck | 4.7 | 0.0 | 8.0 | 3.8 |

Brick-making was also reported by substantial proportions of sample respondents in all three locations as a strategy for improving their livelihood. The respondents at Swaswa Bwawani accounted for the largest percentage (40.5%) followed by their counterparts in Swaswa North and Swaswa Mbuyuni who accounted for 38.4% and 18.0%, respectively (Figure 1). Through observation, it was noted that many housing structures in the area were made of muddy bricks (Plate 2). This partly explains why brick making is an important economic activity in the area.

It was, however, observed that local technology is used in making the bricks and in the construction of the temporary muddy structures. It was also established from the FGD that lack of awareness, risk of handling wastewater, poor technology and lack of market, are the main reasons for low production of muddy bricks.

Elsewhere, Deng *et al.* (2010) found that wastewater sludge can be used as raw materials for making bricks, concrete filler and concrete aggregates. Therefore, it is evident from the findings of this study that the reuse of wastewater sludge as construction materials offers a technically feasible alternative for sludge disposal.

It was also revealed that few respondents in Swaswa are involved in fishing activities presumably because Dodoma Urban Water and Sewerage Authority (DUWASA), the water utility in the area has prohibited fishing practices to protect consumers against health hazards. This is mainly because fishing is practiced at the receiving pond where fish feed on fresh human excreta. The survey respondents and FGD participants acknowledged that fishing is practiced by very few people, but secretly. This mirrors the findings by Buechler and Devi (2003) in India who found that wastewater is also used for fishing activities.

**Plate 2: Mud bricks and houses constructed by mud bricks at Swaswa**

**Extent of wastewater utilization for economic activities**

The discussion in the previous section shows that there is low utilization of wastewater in the study area. Only paddy irrigation, horticulture, construction and domestic animal watering activities are practiced. Table 4 summarizes the potential activities which could be done in the study area versus those that are currently practiced. The findings show that out of the 13 potential activities that could be conducted at Swaswa, only four activities which is equivalent to 31 percent are currently practiced in the area. This shows that the potential of wastewater as a resource for different economic activities has not been fully utilized in the study area. This parallels the findings by Scott *et al.* (2007) who concluded that in developing countries, wastewater has been used for irrigating crops, fodder, parks and recreation areas, horticulture, floriculture, aquaculture, domestic animal watering, cleaning, washing, industrial activities, building, biogas processing and organic fertilizer making.

**Table 4: General and Swaswa wastewater activities**

| Activities | Activities in Swaswa |
|---|---|
| Crops irrigation (paddy) | √ |
| Horticulture | √ |
| Floriculture | × |
| Buildings | √ |
| Aquaculture | × |
| Fodder irrigation | × |
| Domestic animal watering | √ |
| Cleaning and washing | × |
| Industrial activities | × |
| Watering of City/ town gardens and playing grounds | × |
| Sludge processing as fertilizer | × |
| Biogas generation | × |
| Parks and recreation areas | × |

√=utilized ×=not utilized

**Conclusion**

This study provides empirical evidence relating to wastewater utilization for economic activities. The analysis identifies the main economic activities that currently utilize wastewater in the study area, including farming, livestock keeping and bricks making. However, the extent of wastewater utilization in respect to respondents' activities is generally low. While more than twelve wastewater activities could be practiced in the study area, less than one-third of these activities are currently practiced. Thus, the main conclusion emerging from this study is that despite the existing economic activities that utilize wastewater, wastewater is generally underutilized in the study area. This calls for deliberate efforts by policy makers and other stakeholders to exploit the full potential of

wastewater for purposes of improving livelihood of communities surrounding Swaswa ponds and other areas in the country. Such measures could include: community participation on how to plan for using wastewater potentials, construction of irrigation structures, dips and fish ponds, and mobilizing clean and wastewater uses cost sharing which could be used for maintenance and repair of water structures, dips and fish ponds. In addition, the responsible authorities and stakeholders could consider formation of wastewater users' groups to enhance the coordination between wastewater users and responsible authorities for technical assistance, extension services, financial services and social services.

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