



Local Residents' Preferences for the Delivery of Ecosystem Services of Urban Freshwater Ecosystems in Developing Countries; A Case Study of Ngerengere River, Morogoro

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Abstract

Effective management and future restoration efforts of urban riverine ecosystems require a deep understanding of how various residents prefer and rely on different types of ecosystem services (ES). We used both qualitative and quantitative data collection methods including a household-level questionnaire ($n=502$) with a set of structured and semi-structured questions administered through face-to-face interviews with local residents and field observations. To avoid bias, the local residents involved in the survey were selected randomly from households of Morogoro Municipality to understand their social preferences for ecosystem services (ES) of the urban watershed of Ngerengere River and key threats that affect the delivery of ES. Four categories of ES include provisioning services (PS), regulating services (RS), cultural services (CS) and supporting services (SS). The study revealed that a significant proportion of respondents perceived the role of urban rivers in provisioning services such as urban water supply (37.60%), in regulating services, respondents acknowledged the role of urban rivers in groundwater recharge (52.3%) while in supporting services respondents preferred key services such as biodiversity of fish (39.5%) and the fertility of soil (21.4%), furthermore for cultural services respondents preferred recreation services of urban rivers of (42.5%). Based on the binary logistic regression, the study revealed that personal and residential factors influence preference heterogeneity on ES. Assessment of the existing threats to ES of urban rivers stems from urbanization and human activities, adversely affecting regulatory, cultural, and supporting services, which in turn lowers residents' preferences for these ecosystem services. The study concludes that incorporating local resident perceptions of ES into decision-making can support future management and restoration initiatives on urban rivers to enhance their potential in ES provisioning.

Keywords: Ecosystem services, Ngerengere, Morogoro Municipality, Urban river ecosystems, Local residents' preferences

1 Introduction

Ecosystem services (ES) encompass the direct and indirect advantages that individuals gain from diverse ecosystem types (Francis, 2014; Khoroshi et al., 2016; Garau et al., 2020). The Millennium Ecosystem

Assessment (MEA) broadly defines ecosystem services as provisioning, regulating, cultural, and supporting services that humans derive from the ecosystem (MEA, 2005). Within freshwater ecosystems, rivers offer a range of ecosystem services, such as freshwater provision, fish supply,

transportation, waste absorption, recreational opportunities, tourism, and biodiversity preservation (Miah et al., 2021). In this regard, numerous urban centres have emerged along rivers because of the resources and services they offer (Everard & Moggridge, 2012). Since 2008, most of the world's population has resided in urban areas, and this trend persists (UN World Urbanization Prospects, 2019). Projections indicate that by 2030, urbanization will encompass 60% of the global population (Syrbe et al., 2021). Because urban areas have high population densities, there is potentially significant demand for ecosystem services, particularly those provided locally. A healthy ecosystem status entails sufficient biophysical structures, like habitats, and supports ecological processes, such as primary production. In contrast, a degraded ecosystem status lacks the potential to deliver such functions, ultimately reducing the benefits to human well-being in the form of ecosystem services (Beißler & Hack, 2019).

In Tanzania, various aquatic ecosystems offer socially and economically significant ecosystem services (Kaaya & Lugomela, 2015). The country is unique in its territorial jurisdiction over all three of the African Great Lakes and is intersected by several major river systems, including the Rufiji, Mara, Malagarasi, Pangani, Ruvuma, Wami, and Ruvu Rivers. While the lakes are acknowledged worldwide as focal points for species diversification, Tanzania's rivers, though less renowned on a global scale, play a significant role in maintaining a large portion of the country's freshwater and terrestrial biodiversity. Additionally, these rivers serve as vital water sources to sustain the expanding human population, particularly in urban centres (Seeteram et al., 2019). Previous research efforts on aquatic ecosystem services in the Wami River and its estuary in Tanzania, examined stakeholders' perceptions of the ecosystem services of the riverine ecosystem and indicated the significant importance of the provision of domestic water, habitat for wildlife, tourism, and erosion control (McNally et al., 2016a).

Food and fresh water were also identified as the most crucial provisional services for livelihood, particularly in both irrigation and rainfed farming

practices, notably for the inhabitants of the Kilombero Valley (Alavaisha & Lindborg, 2022). The Ngerengere River serves as the primary watercourse draining the Ngerengere sub-catchment, which is among the catchments in the Wami-Ruvu basin in Tanzania. This catchment acts as the origin of the water supply for the urban regions of Morogoro Municipality, as it directs its water flow into the Mindu reservoir (Shagega et al., 2020). The major urban centres of Morogoro are all situated within the catchment area of the Ngerengere River. Due to the high population density of urban areas, there is a significant demand for freshwater ecosystem services, especially those provided on-site (Miraji et al., 2019).

Urbanization is regarded as one of the most significant transformations of freshwater ecosystems. In that regard, urban rivers are subjected to various environmental challenges, including point and non-point sources pollution, habitat degradation, altered flow patterns, and flooding urbanization (Francis, 2014). These changes intensify pressure on these systems, reducing their capacity to deliver a sufficient array of ecosystem services (Garau et al., 2020). As freshwater ecosystems face ongoing degradation and destruction globally, human society is losing the wealth of ecosystem services that healthy freshwater environments offer. As a result, there is a growing acknowledgement of the imperative to restore and sustainably manage urban freshwater ecosystems (Everard & Moggridge, 2012).

Consequently, urban ecosystems remain vital areas for research in the field of ecosystem services (Kremer et al., 2016). According to the Millennium Ecosystem Assessment (MEA), approximately 60% of global ecosystem services have been endangered or utilized inappropriately (Deeksha & Shukla, 2022). This trend is projected to persist, particularly throughout the first half of the current century. In recent times, there has been a noticeable rise in scholarly attention, as evidenced by several special issues in international journals, towards the field of ecology and the ecosystem services offered by urban areas (Haase et al., 2014; Schwarz et al., 2017). The concept of ecosystem services encourages problem-solving by highlighting the social benefits that intact

water bodies and riparian areas can provide (Hack, 2015). By identifying the potential for ecosystem services, it is assumed that urban water pollution could be reduced, and urban rivers in developing and emerging countries could be maintained in a more natural state. However, there is a lack of widely accepted methodology for evaluating the value of urban rivers and riparian areas in their ability to provide ecosystem services (Liu, 2014).

There have been advancements in and applications of ecological and economic methodologies for assessing ecosystem services (De Groot et al., 2002). In contrast to ecological and economic methodologies, social approaches are more adept at capturing the complexities of social-ecosystem interactions. Integrating stakeholders' perceptions of ecosystem services (ES) into regional sustainable strategies and management is essential for ensuring the sustainable provision of ES upon which human beings rely (Orenstein & Groner, 2014). Therefore, recently researchers have examined stakeholders' perceptions regarding freshwater ES (McNally et al., 2016; Zhang et al., 2019; García-Llorente et al., 2020; Nyangoko et al., 2020). Stakeholders' perceptions of ecosystem services (ES) were characterized by their understandings and viewpoints regarding the concept of ES. The objectives of these studies primarily fall into four categories; (1) to compare and contrast the utilization and perspectives of upstream and downstream residents (residential time ≥ 1 year) living adjacent to the rivers, regarding the value of ecosystem services (2) identify their perceptions regarding the major threats to freshwater ecosystem services, (3) to assess the influence of different biophysical and socio-demographic on the local residents' perceptions on freshwater ecosystem services.

The use of social approaches in evaluating the utilities of freshwater ecosystems in Tanzania has been reported by (Janssens De Bisthoven et al., 2020) in Lake Manyara Basin, (Nyangoko et al., 2022) in Rufiji Delta, (Koko et al., 2020) in Kilombero Basin, and (Ndetewio et al., 2013) in Moshi-Pangani; However, there is inadequate research on ES of urban freshwater ecosystems in Tanzania using social

methods. Therefore, the Urban catchment of the Ngerengere drains in Morogoro Municipality was selected to study stakeholders' perceptions of ecosystem services by considering factors such as the ecological and societal roles of urban rivers within the larger urban systems (Francis, 2012), the population (Lhoest et al., 2019), urbanization and the increased risk of ecological potential of urban rivers (Beißler & Hack, 2019). The novelty of this study lies in the inclusion of other residential factors (distance from the river and residential time) and partitioning of the residential area into the upstream, midstream, and downstream reaches of the Ngerengere River drain within the Morogoro Municipality.

Mack et al., (2024) reported that the ES concept has largely been studied in developed countries while in developing countries there were significant research efforts made in rural areas compared to urban landscapes, particularly freshwater ecosystems in the African region. Nevertheless, the information and data on how urban residents experience, value and perceive the ES of urban rivers remains uncertain. Therefore, it is worthy to assess local people's perceptions of ecosystem services in urban landscapes in order to explore those ES that are most important to local residents. Also, it can document the ES that local residents are willing to conserve due to their perceived significance and value. Thirdly, assessment of the perception of ES by urban communities can provide baseline information for collective actions to address the ecological degradation of urban river systems and inform the stakeholders on the design and execution of ecological interventions that are compatible with local values.

The main purpose of this study is to evaluate the variations in consumptive and non-consumptive ecosystem services of Urban rivers within the Morogoro Municipality in Tanzania. The specific objectives were to: (1) assess the river ecosystem services preferences perceived by local residents in Morogoro Municipality (with a residential time ≥ 1 year, age ≥ 18 years old); (2) explore primary threats towards ES provided by urban rivers in Morogoro Municipality (3) evaluate local resident awareness on

the issues related to the ecosystem services of urban rivers and their overall management

2 Materials and Methods

2.1 Study Area

stemming from the discharge of household waste, sewage, industrial effluents, agricultural practices, and fishing activities (Mdegela et al., 2009; Chen et al., 2022). Additionally, the Ngerengere River has been incorporated into the urbanized zone owing to

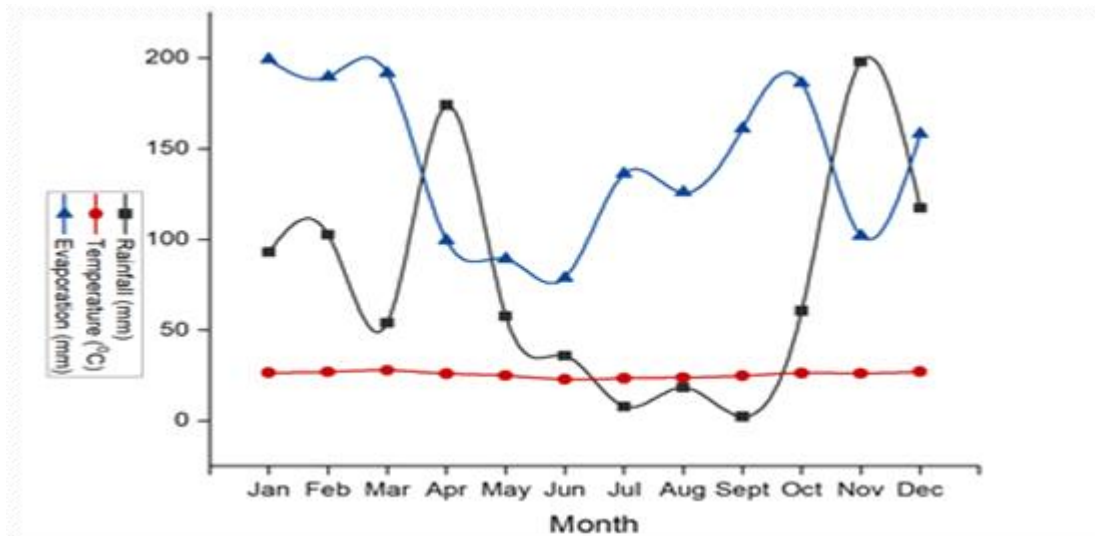


Figure 1: Climate Data for Morogoro Municipality in 2023: Rainfall, Temperature, and Evaporation (Source, TMA, 2024)

The Ngerengere River Catchment (NRC) area lies in the middle of the Wami-Ruvu sub-basin, situated between approximately $6^{\circ} 30' 00''$ and $7^{\circ} 10' 00''$ south latitude, and $37^{\circ} 58' 26''$ and $38^{\circ} 31' 30''$ east longitude, covering around 2780 square kilometers. Originating from the Uluguru mountains, the river spans a significant portion of the Morogoro Region, including the Morogoro Urban District and parts of the Morogoro Rural District (Shagega et al., 2019). Within this catchment, there is a single dam, the Mindu Dam, which serves as a crucial freshwater source for urban areas in Morogoro, supporting various activities such as agriculture and fishing (Raphael et al., 2023a). Eventually, the river merges with the lower Ruvu River, contributing to its flow towards the Indian Ocean. This study focuses on the segment of the Ngerengere River and its three tributaries namely; Bigwa, Kikundi and Morogoro within Morogoro Municipality, aligning with specific research objectives. The urban centre of Morogoro Municipality, with over 471,409 inhabitants, is where the Ngerengere River drains.

The present condition of these water sources is characterized by elevated levels of pollution

stemming from the discharge of household waste, sewage, industrial effluents, agricultural practices, and fishing activities (Mdegela et al., 2009; Chen et al., 2022). Additionally, the Ngerengere River has been incorporated into the urbanized zone owing to swift urban growth witnessed over the past few decades. Moreover, the removal of vegetation along the riverbanks is becoming a growing concern, disrupting the river's ecology (Lalika, 2021). Nevertheless, inhabitants, particularly those in the Morogoro Municipality communities situated along the river, rely on the river water and nearby natural wells for their daily needs. The variations in the discharge of the Ngerengere River catchment are highly influenced by the runoff originating from the Uluguru Mountains (Natkhin et al., 2015). However, alterations in the flow patterns have been noted over the past few decades in various research studies conducted in tropical catchments across Tanzania (Mtalo et al., 2005; Mwakalila, 2011).

In addition to fluctuations in annual runoff, changes in seasonal discharge patterns have also been observed. Generally the discharge regime is frequently altered by both the impacts of climate change and anthropogenic modifications within the catchments (Kashaigili, 2008). Situated within the tropical climate belt, the catchment experiences two primary rainy seasons. Annual precipitation across much of the catchment ranges from 800 to 1,000 mm

per year, but in the Uluguru Mountains, it surpasses 1,500 mm per year (Natkhin et al., 2015). During the data collection year 2023, climatological data from the Tanzania Meteorological Authority (TMA) showed that Morogoro Municipality experienced varied rainfall patterns and temperatures, with notable precipitation peaks in April, November, and December (Figure 1). These climatic fluctuations may have significant implications for ecosystem services provided by the Ngerengere River, potentially affecting water availability, water quality, and overall ecological health (Schaefer & Dietrich, 2016).

2.2 Research Design

This study employed a one-time data collection approach using a cross-sectional design (Raphael et al., 2023). Fieldwork was conducted to collect quantitative and qualitative data from February to March 2024, encompassing community and household levels, to investigate local perceptions of ecosystem services provided by urban rivers (Ngerengere, Kikundi, Bigwa, and Morogoro) within the Ngerengere River Catchment, as well as the factors influencing these perceptions. Data collection involved a household questionnaire survey (HHQ) and field observations, a combination of these two methods was employed to ensure cross-checking and validation of collected information (Nyangoko et al., 2020). Before data collection, participants were briefed on the study's objectives and requested consent to participate. Respondents were purposively selected with the assistance of village leaders, focusing on individuals who had some level of interaction with urban rivers, as they were presumed to possess valuable knowledge and information about the rivers.

The cross-sectional design was used over the longitudinal design by our household survey that focused on residents who possess directly lived experiences (> 1 year) with their surrounding environment to gain their overall insights into both dry and wet season spells.

2.2.1 Sampling

The research utilized a face-to-face structured and semi-structured questionnaire built from existing

literature and taking into account the catchment characteristics (Wei et al., 2018; Zhang et al., 2019) to establish the sampling points. Households were randomly approached at the upstream (less inhabited mountainous areas), and in midstream and downstream areas (inhabited areas) sample points were spaced adequately to accurately reflect residents' perceptions of ecosystem services see Figure 2. Therefore, criteria such as population and residential factors (distance from the river, Municipality boundaries and residential time which were supposed to be > 1 year) were considered to obtain a representative sample to study the residents' perceptions of ES.

Considering the drainage of the urban catchment, upstream areas are those wards that were located in the proximity to headwater i.e. Uluguru mountains, the hydrologic processes in these areas also influence the hydrologic processes in the midstream and downstream areas (Alexander et al., 2007). Midstream areas comprise those selected wards that are located in the centre of the urban catchment where there is a mix of different human activities. Downstream areas constitute those wards located approximately 0.3 to 2.7 km from midstream to allow for the mixing of pollutants that might be attributed to midstream and upstream activities.

Following the principle of minimum sample size selection (Reddy & Henze, 2023), the calculation for the minimum sample size is conducted using the following formula.

$$N = \frac{Z^2 \times P \times (1-P)}{E^2} \quad (1)$$

Where N is the required minimum sample size, Z is the Z-score value corresponding to the desired confidence level $Z=1.96$ (for a 95% confidence level), E represents the margin of error and for a 95% confidence interval $E=5\%$, and $P=0.5$, then N value is 384. For this study, a minimum sample size of 384 participants is required. However, in this study total of 502 questionnaires were administered to the local residents of the Municipality to accommodate the demographic dynamics and the characteristics of the study area catchment (Wei et al., 2018). The allocation of the study sample among the 8 wards

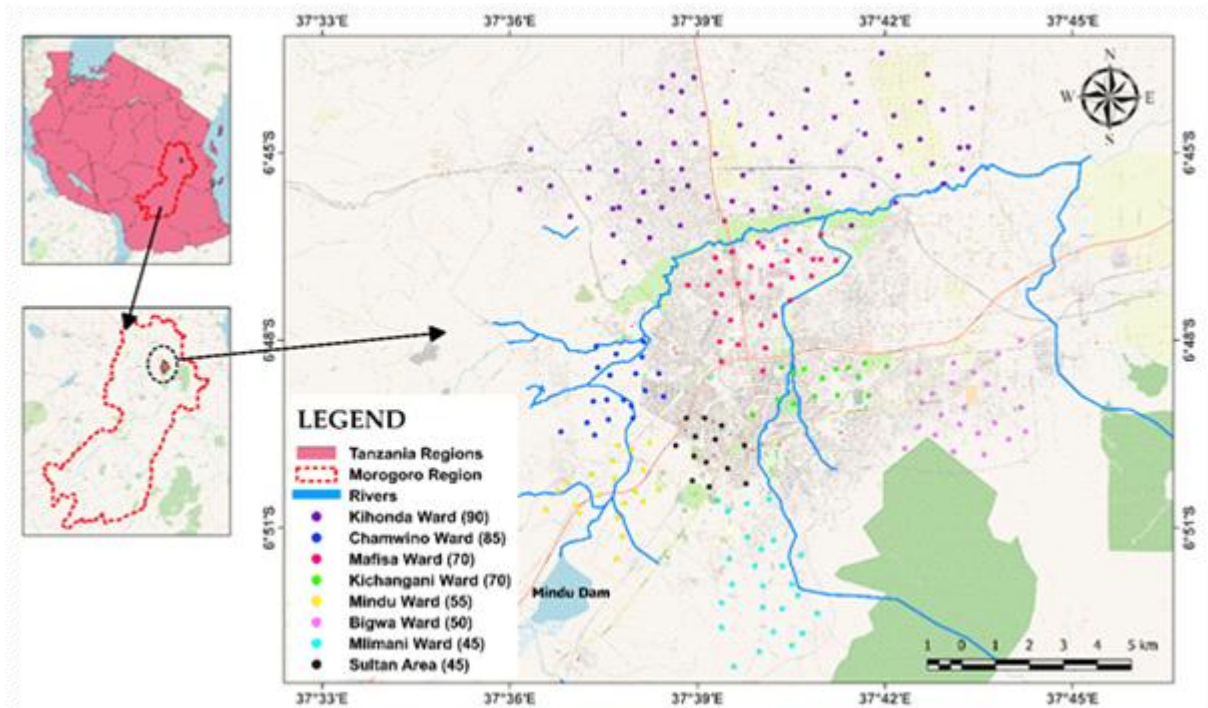


Figure 2: Selected households across the urban rivers in the Morogoro Municipality

drained by urban rivers within Morogoro Municipality is illustrated in Table 1.

2.3 Questionnaire Design

Considering socioeconomic and catchment characteristics, the questionnaire used in this study

regulating, supporting, cultural, and provisioning (Table 2). While other studies delineated nutrient cycling and soil formation as distinct supporting services, we opted to consolidate them under the umbrella term "habitat," considering that changes in

Table 1: Allocation of the sample size by wars drained by Ngerengere River and its tributaries at the Morogoro Municipality

Ward	Number of households	Sample size	Percentage (%)
Kihonda	9,412	90	17.93
Chamwino	8,380	85	16.93
Mafisa	7,280	70	13.94
Kichangani	7,107	70	13.94
Mindu	5,792	50	9.96
Bigwa	4,345	45	8.96
Mlimani	1,642	40	7.97
Sultan Area	732	42	8.37
Total		502	100

was developed concerning previous questionnaires used by (McNally et al., 2016; Zhang et al., 2019). Similar to their methodology, the questionnaire selected four (4) categories of ecosystem services outlined in the Millennium Ecosystem Assessment:

nutrient cycling significantly impact habitat quality (McNally et al., 2016). The survey did not explicitly employ the term "ecosystem services"; instead, it focused on highlighting the benefits that individuals directly derive from urban rivers (Lhoest et al., 2019).

Table 2: The ecosystem services incorporated within the household questionnaire survey

Ecosystem service category	Ecosystem services
Provisioning	Urban water supply, water for livestock, irrigation water, industrial water supply, fish production, capturing fishes, natural medicine and pharmaceuticals and biochemicals, aquaculture, wild foods and other aquatic animals, river weeds, riverbank gardens, hydropower, sand and gravel, timber from aquatic and riverbank trees and plants, fibre from aquatic plants (water hyacinths, reeds), floating woods (fuel wood), genetic resources
Cultural	Recreation, transport and navigation, education and research, eco-tourism, protected areas, cultural values e.g. festivals and boat racing, locational values e.g. near confluences of rivers, aesthetic values – landscape contribution, spiritual and religious values of rivers, political and administrative boundaries.
Supporting	Biodiversity fish, primary production – photosynthesis, fertility of alluvium or sediment, soil formation riverbed and banks – floodplain, pollination and dispersal of aquatic plants, fish migration routes, erosion and sediment transport – sediment deposition, biodiversity – water birds and mammals, natural hazard regulation – flash flood risks, erosion and sediment transport – the source of sediment, natural hazard regulation – dispersion of flood waters, biodiversity – other aquatic plants and animals, biodiversity rare, threatened or endemic species, nutrient cycling and transport, habitat for bird nesting, habitat for connectivity, habitat for bird migration, habitats for spawning and growing, habitats – uniqueness, habitat for refuge e.g. deep pools
Regulating	Groundwater recharge, maintaining water quality, wastewater treatment - water purification, maintaining air quality, water-borne disease regulation pest regulation, local climate regulation/moderation, surface water sources, groundwater discharge, carbon emissions/carbon capture, local climate regulation/moderation, natural hazard regulation-water storage for drought risk reduction, natural hazard regulation – dispersion of flood waters, natural hazard regulation – flash flood risks, erosion and sediment transport – sediment deposition, erosion and sediment transport – the source of sediment

Before administering the survey, the questionnaire underwent testing with seven local experts who specialize in relevant scientific fields. The questionnaire comprises four sections: (1) Residential factors including details like residential area, habitation, and duration of residency; (2) Residents' preferences for Ecosystem Services (ES) of urban rivers in the Municipality; (3) To capture relevant information on key threats to ES of urban rivers in the Morogoro Municipality (4) Demographic characteristics of residents including gender, age, occupation, personal monthly income, and education level.

2.4 Data Analysis

Data collected from household surveys (quantitative data) was inputted into statistical software namely Stata version 17. In analyzing this study, both descriptive and inferential statistical methods were employed to explore the demographic factors influencing awareness near river streams. Descriptive statistics were used to summarize and describe the characteristics of the sample population. This included computing measures such as frequencies, and percentages for demographic variables like sex, age categories, as well as eco-services influencing variables. These descriptive statistics provided a clear overview of the

Table 3: Socio-demographic characteristics of respondents (n=502)

Variables	Categories	Frequency	Percentage (%)
Sex of the Respondent	Female	230	45.8
	Male	272	54.2
Age category of respondents	Below 18	0	0.0
	18 - 25	29	5.8
	26 - 45	298	59.4
	46- 60	146	29.1
	Above 60	29	5.8
Occupation of respondents	Employed	66	13.1
	Business	144	28.7
	Self Employed	47	9.4
	Farmer	224	44.6
	Student	5	1.0
	Unemployed	16	3.2
Education background	Adult Education	24	4.8
	Secondary Education	125	24.9
	Certificate	71	14.1
	Diploma	52	10.4
	Informal education	30	6.0
	Primary Education	113	22.5
	University	50	10.0
	Vocational training	37	7.4
What is your monthly gross income in TZS?	Below 100,000	115	22.9
	100,000-300,000	183	36.5
	300,000-500,000	156	31.1
	500,000-1,000,000	35	7.0
	Above 1,000,000	13	2.6
Household size category	Below 3 members	60	12.0
	3 - 5 members	267	53.2
	6 - 10 members	172	34.3
	Above 10 members	3	0.6
Years of familiarity with the environment	Below 3 years	41	8.2
	3 - 5 years	97	19.3
	6 - 10 years	143	28.5
	Above 10 years	221	44.0

demographic composition of the respondents and their distribution across different categories. Additionally, inferential statistical analyses were conducted to uncover relationships, and associations between variables and their impact on awareness. The inferential analysis primarily involved a binary logistic regression model using a statistical model that allowed for the assessment of the odds ratios for the factors impacting the perception and preferences of the local residents on the ES of the urban river. The odds ratios, standard errors, t-values, and p-values were computed for each variable, allowing for a

detailed assessment of their significance in predicting preferences. This model was selected because it can analyze the effects of categorical explanatory variables. The variables included in the model were defined based on the link between a binary dependent (response) variable and one independent (predictor) variable, which was either categorical. The selection of the 7 variables in the model considered the fact that the residents have different social groups that directly or indirectly rely on urban rivers to support their livelihoods and well-being.

3 Results and Discussion

3.1 Demographic Characteristics of Respondents

This survey on community perceptions of

distribution suggests a relatively balanced participation in the survey, which could provide a comprehensive perspective on community perceptions

Table 4: Preference of respondents on the provisioning services of Urban rivers in the Morogoro Municipality (n=502)

Provisioning services for rivers	Not preferred		Preferred		Total		Person Chi-square test		
	Freq	Per	Freq	Per	Freq	Per	2	df	Sig
Urban water supply	98	19.50%	189	37.60%	287	57.20%	1.894	1.00	0.169
Water for livestock	74	14.70%	195	38.80%	269	53.60%	4.643	1.00	0.031*
Irrigation water	60	12.00%	254	50.60%	314	62.50%	61.167	1.00	0.000*
Industrial water supply	28	5.60%	147	29.30%	175	34.90%	30.495	1.00	0.000*
Fish production, capturing fishes	33	6.60%	102	20.30%	135	26.90%	4.459	1.00	0.035*
Natural Medicine and pharmaceuticals and biochemicals	26	5.20%	53	10.60%	79	15.70%	0.066	1.00	0.797
Aquaculture	13	2.60%	22	4.40%	35	7.00%	0.52	1.00	0.471
Wild foods and other aquatic animals	6	1.20%	32	6.40%	38	7.60%	4.793	1.00	0.029*
River weeds	11	2.20%	23	4.60%	34	6.80%	0.008	1.00	0.93
Riverbank gardens	5	1.00%	25	5.00%	30	6.00%	3.32	1.00	0.068
Hydropower	2	0.40%	2	0.40%	4	0.80%	0.626	1.00	0.427
Sand and gravel	3	0.60%	17	3.40%	20	4.00%	2.676	1.00	0.102
Timber from aquatic and riverbank trees and plants	1	0.20%	5	1.00%	6	1.20%	0.632	1.00	0.427
Fibre from aquatic plants (water hyacinths, reeds)	1	0.20%	1	0.20%	2	0.40%	0.312	1.00	0.577
Floating woods (fuel wood)	2	0.40%	2	0.40%	4	0.80%	0.626	1.00	0.427
Genetic resources	1	0.20%	0	0.00%	1	0.20%	2.162	1.00	0.142

* The Chi-square statistic is significant at the 0.05 level.

ecosystem services of urban rivers within the Morogoro Municipality captures a diverse range of socio-demographic characteristics among 501 respondents. Through examination of variables such as gender, age, occupation, education, income, household size, and familiarity with the environment, the survey provides a comprehensive overview of the population's background. These demographic characteristics suggest that respondents have substantial life and work experience in the study area, which likely provides them with informed perspectives on local ecosystem services provided by urban rivers. The survey results in Table 3 show among 501 respondents a slight majority were male (54.2%) compared to female (45.8%). This gender

regarding ecosystem services.

However, the slight male predominance may indicate gender-related factors influencing survey participation, such as availability, interest, or societal roles. The age distribution of respondents is skewed towards the middle-aged group, with the majority (59.4%) being between 26 and 45 years old. This group is likely the most active economically and socially, which might explain their high representation. The next significant group is aged 46 to 60 years (29.1%), followed by the younger and older age groups, each comprising 5.8% of the respondents. The absence of respondents below 18 suggests a focus on adult perspectives in the survey, was due to legal and ethical considerations in survey

administration. Occupational data shows that farming is the predominant occupation (44.6%), reflecting the moderate level of formal education overall. A significant number have certificates (14.1%) and

Table 5: Preferences of respondents on regulating services of rivers in the Morogoro Municipality (n=502)

Regulating services of rivers in your community	Not preferred		Preferred		Total		Person Chi-square test		
	Freq	Per	Freq	Per	Freq	Per	2	df	Sig
Groundwater recharge	79	15.8%	262	52.3%	341	68.1%	36.193	1	0.000*
Maintaining water quality	60	12.0%	153	30.5%	213	42.5%	2.177	1	0.14
Wastewater treatment – water purification	55	11.0%	97	19.4%	152	30.3%	1.992	1	0.158
Maintaining air quality	23	4.6%	87	17.4%	110	22.0%	7.627	1	0.006*
Water-borne diseases regulation	18	3.6%	169	33.7%	187	37.3%	67.331	1	0.000*
Pest regulation	37	7.4%	88	17.6%	125	25.0%	0.351	1	0.554
Local climate regulation/moderation	18	3.6%	49	9.8%	67	13.4%	0.847	1	0.357
Surface water sources	22	4.4%	37	7.4%	59	11.8%	0.951	1	0.329
Groundwater discharge	7	1.4%	17	3.4%	24	4.8%	0.077	1	0.782
Carbon emissions/carbon capture	8	1.6%	4	0.8%	12	2.4%	6.924	1	0.009*
Local climate regulation/moderation	0	0.0%	2	0.4%	2	0.4%	0.934	1	0.334
Natural hazard regulation-water storage for drought risk reduction	3	0.6%	14	2.8%	17	3.4%	1.612	1	0.204
Natural hazard regulation – dispersion of flood waters	5	1.0%	19	3.8%	24	4.8%	1.383	1	0.24
Natural hazard regulation – flash flood risks	5	1.0%	42	8.4%	47	9.4%	10.657	1	0.001*
Erosion and sediment transport – sediment deposition	9	1.8%	49	9.8%	58	11.6%	7.965	1	0.005*
Erosion and sediment transport – the source of sediment	5	1.0%	46	9.2%	51	10.2%	12.607	1	0.000*

* The Chi-square statistic is significant at the 0.05 level.

agrarian nature of Morogoro. Business (28.7%) and employment in various sectors (13.1%) are also significant. The presence of self-employed individuals (9.4%) a small percentage of students (1.0%) and unemployed respondents (3.2%) highlights the diverse economic activities within the community. This diversity in occupation can influence the community's valuation and dependence on ecosystem services differently.

Education levels among respondents vary, with the largest groups having secondary education (24.9%) and primary education (22.5%). This indicates a

diplomas (10.4%), while a smaller group has attained university education (10.0%). The presence of informal education (6.0%) and adult education (4.8%) points to efforts in continuing education and skill development within the community. Vocational training, held by 7.4%, indicates a focus on practical skills relevant to the local economy. Income distribution shows that the majority earn between 100,000 and 300,000 TZS (36.5%), followed by those earning 300,000 to 500,000 TZS (31.1%). A notable portion earns below 100,000 TZS (22.9%), reflecting a segment of the population with lower economic

means. Fewer respondents earn between 500,000 and 1,000,000 TZS (7.0%) and above 1,000,000 TZS (53.2%) or 6 to 10 members (34.3%), indicating relatively large family sizes.

Table 6: Preferences of respondents on supporting services of rivers in the community (n=502)

Supporting services of rivers in your community	Not preferred		Preferred		Total		Person Chi-square test			
	Freq	Per	Freq	Per	Freq	Per	2	df	Sig	
Biodiversity fish	66	13.2%	198	39.5%	264	52.7%	11.69	1.00	0.000*	
Primary production – photosynthesis	80	16.0%	172	34.3%	252	50.3%	0.00	1.00	0.996	
Fertility of alluvium or sediment	35	7.0%	107	21.4%	142	28.3%	4.596	1.00	0.032*	
Soil formation riverbed and banks – floodplain	39	7.8%	95	19.0%	134	26.7%	0.585	1.00	0.444	
Pollination and dispersal of aquatic plants	42	8.4%	84	16.8%	126	25.1%	0.198	1.00	0.656	
Fish migration routes	26	5.2%	60	12.0%	86	17.2%	0.108	1.00	0.742	
Erosion and sediment transport – sediment deposition	10	2.0%	65	13.0%	75	15.0%	13.789	1.00	0.000*	
Biodiversity – water birds and mammals	20	4.0%	49	9.8%	69	13.8%	0.28	1.00	0.597	
Natural hazard regulation – flash flood risks	7	1.4%	59	11.8%	66	13.2%	15.666	1.00	0.000*	
Erosion and sediment transport – the source of sediment	7	1.4%	57	11.4%	64	12.8%	14.651	1.00	0.000*	
Natural hazard regulation – dispersion of flood waters	4	0.8%	43	8.6%	47	9.4%	12.914	1.00	0.000*	
Biodiversity – other aquatic plants and animals	5	1.0%	20	4.0%	25	5.0%	1.673	1.00	0.196	
Biodiversity – rare, threatened or endemic species	6	1.2%	14	2.8%	20	4.0%	0.28	1.00	0.597	
Nutrient cycling and transport	2	0.4%	15	3.0%	17	3.4%	3.24	1.00	0.072	
Habitat for bird nesting	0	0.0%	9	1.8%	9	1.8%	4.261	1.00	0.039*	
Habitat for connectivity	1	0.2%	7	1.4%	8	1.6%	1.389	1.00	0.239	
Habitat for bird migration	1	0.2%	3	0.6%	4	0.8%	0.084	1.00	0.771	
Habitats for spawning and growing	0	0.0%	4	0.8%	4	0.8%	1.875	1.00	0.171	
Habitats - uniqueness	1	0.2%	2	0.4%	3	0.6%	0.004	1.00	0.952	
Habitat for refuge e.g. deep pools	1	0.2%	1	0.2%	2	0.4%	0.309	1.00	0.578	

* The Chi-square statistic is significant at the .05 level.

(2.6%). This income spread suggests varying levels of economic stability and potential differences in reliance on ecosystem services for livelihoods. Most respondents live in households with 3 to 5 members

A smaller proportion has households with fewer than 3 members (12.0%), and very few have more than 10 members (0.6%). Household size can influence resource use and dependency on local

ecosystem services of urban rivers, with larger households potentially placing more pressure on these resources. The respondents' familiarity with the local environment is substantial, with 44.0% having lived in the area for more than 10 years. Another significant group has 6 to 10 years of familiarity (28.5%), while 19.3% have been in the area for 3 to 5 years. Only a small fraction (8.2%) is relatively new, with less than 3 years of familiarity. This long-term familiarity suggests that most respondents have a deep understanding of the local ecosystem services and their changes over time, providing valuable insights into community perceptions.

3.2 Preferences on Ecosystem Services

In analysing the respondents' preferences for the ecosystem services of urban rivers, the following categories of ES were considered provisioning, regulating, supporting, and cultural. Provisioning services include the supply of water for various uses such as urban water supply, livestock, irrigation, and industrial processes. Regulating services involve the maintenance of water and air quality, disease regulation, and natural hazard mitigation. Supporting services underpin the ecological processes that sustain biodiversity, soil formation, and nutrient cycling. Lastly, cultural services encompass the recreational, educational, aesthetic, and spiritual benefits that rivers offer.

3.2.1 Provisioning Services

The data presented in Table 4 highlight the varying responses among respondents regarding their preferences for provisioning services of urban rivers in their community. The provisioning services include urban water supply, water for livestock, irrigation water, industrial water supply, fish production, and other uses such as natural medicine, aquaculture, and wild foods. A significant proportion of respondents perceived the role of urban rivers in urban water supply (37.60%), water for livestock (38.80%), and irrigation water (50.60%). This observation can be attributed to the direct impact of the aforementioned services on daily life and essential activities of the local residents of the Morogoro Municipality. The Chi-square test results indicate that preferences for water for livestock ($p = 0.031$), irrigation water ($p =$

0.000), industrial water supply ($p = 0.000$), and fish production ($p = 0.035$) is significantly associated with respondents' recognition of these services. The significant Chi-square values suggest that the community's preferences for certain river services are not merely by chance but rather reflect genuine recognition and reliance on these resources. Looking at some provisioning services, the high preference for irrigation water indicates that agricultural activities might be prevalent, relying heavily on river water for crop production. This observation signified that at a household level, consumptive use of river water is the most essential considering the direct contribution to livelihood activities like farming which is the most practised activity (44.6%) by the respondents. Similarly, the significance of industrial water supply preferences points to the presence of industrial activities that depend on rivers for operational needs. Conversely, low preferences and insignificant Chi-square values for services such as natural medicine, aquaculture, and wild foods suggest these are either underutilized or not well-promoted within the community. These discrepancies in preference levels highlight potential areas for community education and policy intervention to maximize the benefits derived from river ecosystems.

3.2.2 Regulating Services

The data presented in Table 5 illustrate the varying preferences among respondents regarding the regulating services provided by rivers in their community. These services include groundwater recharge, maintaining water quality, wastewater treatment, air quality maintenance, and regulation of water-borne diseases, among others. A significant proportion of respondents acknowledged key regulating services such as groundwater recharge (52.3%) and water-borne diseases regulation (33.7%). The Chi-square test results reveal significant associations for several services, indicating that the preferences of these services are not due to random chance. Specifically, preference for groundwater recharge ($p = 0.000$), maintaining air quality ($p = 0.006$), water-borne diseases regulation ($p = 0.000$), carbon capture ($p = 0.009$), flash flood risks ($p =$

0.001), and sediment deposition ($p = 0.005$) show educational and outreach efforts could enhance

Table 7. Preferences of respondents on cultural services of rivers in the community (n=502)

Cultural services of rivers in your community	Not Preferred		Preferred		Total		Person Chi-square test		
	Freq	Per	Freq	Per	Freq	Per	2	df	Sig
Recreation	84	16.8%	213	42.5%	297	59.3%	4.016	1.00	0.045*
Transport and Navigation	48	9.6%	42	8.4%	90	18.0%	23.619	1.00	0.000*
Education and Research	41	8.2%	156	31.1%	197	39.3%	17.884	1.00	0.000*
Eco-tourism	14	2.8%	39	7.8%	53	10.6%	0.775	1.00	0.379
Protected areas	38	7.6%	196	39.1%	234	46.7%	48.675	1.00	0.000*
Cultural values e.g. festivals and boat racing	34	6.8%	70	14.0%	104	20.8%	0.055	1.00	0.814
Locational value e.g. near confluences of river	24	4.8%	56	11.2%	80	16.0%	0.133	1.00	0.716
Aesthetic values – landscape contribution	22	4.4%	84	16.8%	106	21.2%	7.484	1.00	0.006*
Spiritual and religious values of rivers	12	2.4%	39	7.8%	51	10.2%	1.765	1.00	0.184
Political and administrative boundaries	7	1.4%	32	6.4%	39	7.8%	3.711	1.00	0.054

* The Chi-square statistic is significant at the 0.05 level.

statistically significant relationships.

These findings highlight the community's recognition of certain critical regulating services provided by rivers, especially those with direct and noticeable impacts on their daily lives. Looking at the results from Table 5, the high preferences for groundwater recharge and water-borne disease regulation underscores the community's dependence on rivers for essential water supplies, especially the lateral recharge of aquifers by urban rivers and public health promotion by direct abstraction of rivers for domestic activities especially in the upstream areas near the headwater where there are fewer pollution sources than midstream and downstream reaches. Conversely, lower preferences for services such as wastewater treatment and local climate regulation suggest these benefits are either underutilized or not adequately communicated to the public. Furthermore, the low preference for wastewater treatment might also suggest there is controlled discharge of industrial effluents and excreta on the upstream to downstream areas, however, there were a significant number of onsite sanitation systems and industries observed during data collection. The significant Chi-square values for some services indicate targeted areas where

community understanding and utilization of river-related benefits.

3.2.3 Supporting Services

The data in Table 6 show the varying levels of preferences among respondents regarding the supporting services of rivers in their community. Supporting services include biodiversity, primary production, soil formation, pollination, and habitat provision. A significant portion of respondents preferred key services such as the biodiversity of fish (39.5%) and the fertility of soil (21.4%). The Chi-square test results reveal significant associations for several services, indicating that preferences of these services is not random. Specifically, preferences for the biodiversity of fish ($p = 0.000$), fertility of alluvium ($p = 0.032$), erosion and sediment transport ($p = 0.000$), natural hazard regulation for flash flood risks ($p = 0.000$), and habitat for bird nesting ($p = 0.039$) shows statistically significant relationships. These findings underscore the community's recognition of the importance of supporting services that maintain the ecological balance and contribute to the sustainability of the urban river ecosystem. For instance, the high preference for the biodiversity of

fish highlights the community's appreciation of the river's role in sustaining aquatic life, which is crucial for maintaining ecological diversity. The significance of preferences regarding the fertility of alluvium/soil suggests that the community values the role of rivers in enhancing soil quality for agriculture. Conversely, lower preferences for services like habitat for connectivity and bird migration indicate potential gaps in understanding the full range of ecological benefits provided by rivers.

3.2.4 Cultural Services

The data presented in Table 7 highlight the levels of preference among respondents regarding the cultural services provided by rivers in their community. Cultural services considered in this study encompass recreation, transport and navigation, education and research, eco-tourism, and aesthetic values, among others that are most prevalent in urban areas. A significant portion of respondents preferred key services such as recreation (42.5%) and protected areas (39.1%). The Chi-square test results reveal significant associations for several services, indicating that the preferences of these services are not by chance. Specifically, awareness of recreation ($p = 0.045$), transport and navigation ($p = 0.000$), education and research ($p = 0.000$), protected areas ($p = 0.000$), and aesthetic values ($p = 0.006$) show statistically significant relationships. These findings underscore the community's recognition of the importance of cultural services that rivers provide, enhancing the quality of life and contributing to social and cultural well-being. For instance, the high preferences for recreation highlight the community's engagement with rivers for leisure and physical activities, reflecting the role of rivers in promoting health and well-being. Similarly, significant awareness of education and research points to the value placed on rivers as natural laboratories for learning and scientific study. Conversely, lower preferences for services such as spiritual and religious values and political boundaries suggest these aspects are either underrepresented or less emphasized within the community.

3.3 Awareness of Local Communities on Issues Related to Urban River Management

The data in Table 8 highlight the general awareness of the communities situated in proximity to tributaries namely Bigwa, Kikundi, Morogoro, and main Ngerengere River were involved in the survey to evaluate their awareness of pertinent issues governing the management of urban rivers. The findings reveal that certain communities exhibit significantly higher awareness in specific areas, as indicated by the Chi-square tests. Respondents in Morogoro river demonstrate the highest awareness in several categories, notably the role of river management for enhanced provision of ecosystem services/utility (34.1%), river restoration techniques (36.6%), and the importance of vegetation in maintaining river health (36.4%). This suggests that residents near Morogoro river are particularly cognizant of the benefits and conservation needs of their river ecosystems, possibly due to more effective local educational campaigns or greater direct dependency on river resources. On the other hand, local residents from Mindu, Chamwino and Kihonda cited that Ngerengere River stands out in terms of awareness of policies or regulations for river management (35.1%), policies for resources conservation (50.8%), and ecosystem disservices associated with rivers (36.6%). In summary, the overall awareness across all communities is notably high regarding benefits available in river restoration (74.9%) and negative impacts associated with rivers (85.5%), reflecting a widespread understanding of both the positive and negative dimensions of river ecosystems. It was noted that there is a high level of awareness of river restoration and a low awareness of policies suggesting a communication gap. These calls for the importance of continued education and sensitization to local residents on policies and legal frameworks that are relevant in promoting sustainable conservation and utilization of urban rivers.

3.4 Major Threats to Ecosystem Services of Urban Rivers

The data in Table 9 highlight major threats to ecosystem services perceived by local residents of Morogoro Municipality. Among these threats, urban farming (62.4%) and mismanagement of solid waste

(63.3%) emerge as the highest potential risks for water pollution. Urban farming activities can lead to the use of agrochemicals and pesticides, contributing to water contamination, while mismanagement of solid waste can result in leachate and runoff carrying pollutants into rivers. This indicates the potential for

pollution from traffic movement (6.4%) require improved urban planning strategies and green infrastructure to mitigate runoff and air pollutants entering waterways. Table 10 provides insights into the methods used for solid waste disposal near river streams across different communities, including

Table 8: General awareness of respondents on issues related to urban river management (n=502)

Categories	Total		Pearson Chi-Square Tests		
	Freq	Per	2	df	Sig.
Ecosystem services/utility	343	68.3%	55.825	3.00	0.000*
Climate adaptation strategies	229	45.6%	4.602	3.00	0.203
Policies or Plans	111	22.1%	52.504	3.00	0.000*
Acts, regulations or by-laws for resource conservation?	187	37.3%	39.45	3.00	0.000*
River restoration techniques	328	65.3%	80.18	3.00	0.000*
Benefits available in river restoration	376	74.9%	48.176	3.00	0.000*
Bylaws set by your government on water resources management	77	15.3%	13.462	3.00	0.004*
Loss of biodiversity or changes in wildlife habitat along the river	333	66.5%	24.213	3.00	0.000*
Negative impacts or disservices associated with rivers	429	85.5%	20.094	3.00	0.000*
Importance of vegetation in maintaining river health	302	60.3%	25.574	3.00	0.000*

* The Chi-square statistic is significant at the 0.05 level.

agricultural activities to contribute to water pollution using pesticides, fertilizers, and runoff from cultivated lands. Morogoro and Ngerengere rivers, with substantial percentages in this category, may experience heightened water pollution risks due to their agricultural practices. Mismanagement of solid waste is another significant concern, affecting 63.3% of respondents overall. Communities like Morogoro and Ngerengere show higher percentages, reflecting challenges in waste disposal and the potential for solid waste to contaminate river ecosystems. Industrial waste, urbanization, and sewage are also key contributors to water pollution, highlighting the complex interplay of urban development and environmental health. Stormwater management emerges as a critical area of concern, particularly in Ngerengere, where 51.2% of respondents identified it as a risk factor. Poor stormwater management can lead to increased runoff and pollutant discharge into river streams during heavy rainfall, posing threats to water quality and aquatic ecosystems. Additionally, addressing industrial waste (42.6%) and domestic/industrial sewage (42.0%) through stricter regulations and wastewater treatment facilities is essential to safeguard water quality. Lastly, managing stormwater (24.1%) and reducing atmospheric

Bigwa, Kikundi, Morogoro, and Ngerengere Rivers. The significant variations in percentages highlight the diversity in waste management practices and the potential implications for river stream pollution. Open dumping emerges as the most common method, with 63.9% of respondents overall reporting its use. This practice poses significant environmental risks, as it can lead to leachate runoff, soil contamination, and habitat degradation that ultimately end in urban rivers considering the local drainage conditions. The high prevalence of open dumping, especially in communities near Ngerengere River (39.9%) and Morogoro River (33.3%), justifies the urgent need for improved waste management infrastructure and regulations in these areas to protect the pollution and degradation of these rivers.

3.5 Influencing Factors for Resident Perceptions of ES

The binary logistic regression analysis in Table 10 reveals several significant factors influencing preferences for ecosystem services of urban rivers within the Morogoro Municipality. These significant factors include age category, occupation, residential familiarity, educational background, and household size. Several predictors show significant p-values

Table 9: Major threats to the ecosystem services of the urban Rivers within the Morogoro Municipality (n=502)

Category	Total		Bigwa		Kikundi		Morogoro		Ngerengere		Pearson Tests 2	Chi-Square	
	Freq	%	Fr eq	%	Freq	%	Freq	%	Freq	%		df	Sig
Informal sectors	131	26.1	6	4.6	19	14.5	15	11.5	91	69.5	65.4	3	0.000*
Urban farming	313	62.4	24	7.7	77	24.6	79	25.2	133	42.5	35.0	3	0.000*
Mismanagem ent of solid waste	318	63.3	48	15.1	66	20.8	114	35.8	90	28.3	54.7	3	0.000*
Industrial waste	214	42.6	5	2.3	55	25.7	83	38.8	71	33.2	57.5	3	0.000*
Urbanization and rapid population growth	245	48.8	41	16.7	53	21.6	93	38.0	58	23.7	57.7	3	0.000*
Domestic and Industrial sewage	211	42.0	24	11.4	50	23.7	85	40.3	52	24.6	44.3	3	0.000*
Stormwater	121	24.1	9	7.4	34	28.1	16	13.2	62	51.2	28.9	3	0.000*
Automobile Garages	64	12.7	1	1.6	31	48.4	20	31.3	12	18.8	50.9	3	0.000*
Spillage from transportatio n infrastructure	32	6.4	1	3.1	27	84.4	0	0.0%	4	12.5	98.8	3	0.000*
Others	1	0.2	0	0.0	1	100.0	0	0.0	0	0.0	4.4	3	0.221

* *The Chi-square statistic is significant at the .05 level.*

(typically $p < 0.05$), such as: above 10 years of residence ($p = 0.000$), certificate education ($p = 0.035$), vocational training ($p = 0.006$), household size 3 - 5 members ($p = 0.011$), household size 6 - 10 members ($p = 0.001$). These predictors can be considered important factors influencing local residents' preferences. One significant finding is related to years of residence near river streams. Respondents who have lived in the area for more than 10 years show a notably higher odds ratio of 10.581, indicating that longer residency positively influences their preferences regarding ES of urban rivers.

This suggests that individuals who have been part of the community for an extended period are more likely to be concerned about the importance of preserving river ecosystems. Education background

also plays a role in influencing preferences. Respondents with vocational training show a significantly lower odds ratio of 0.16, indicating that higher levels of formal education may lead to increased preferences of ES. Certificate and diploma holders also demonstrate higher odds ratios, albeit to a lesser extent, suggesting that educational attainment beyond secondary education can positively impact preferences of ES. Additionally, household size emerges as a noteworthy factor. Respondents from households with more than 10 members show a substantially higher odds ratio, indicating that larger household sizes may contribute to increased preference levels regarding ES of urban rivers. The Pseudo R-squared value (0.103) indicates that the model explains about 10.3% of the variability in preferences. While this isn't very high, it's typical for

Table 10: Methods used for solid waste disposal near river streams (n=502)

	Total (N)	Per	Communiti es near Bigwa River		Communi ties near Kikundi River		Communitie s near Morogoro River		Communitie s near Ngerengere River		Pearson Square Tests		Chi- Tests Sig
			F	Per	F	Per	F	Per	F	Per	2	df	
Open dumping	321	63.9%	14	4.4%	72	22.4 %	10	33.3% 7	12	39.9% 8	57.9	3	0.000 *
Burying in backyard	226	45.0%	49	21.7%	32	14.2 %	63	27.9%	82	36.3%	36.9	3	0.000 *
Municipal Dumpsite	163	32.5%	36	22.1%	22	13.5 %	53	32.5%	52	31.9%	28.4	3	0.000 *
Open environment and rivers	23	4.6%	1	4.3%	7	30.4 %	4	17.4%	11	47.8%	4.5	3	0.214
Open burning	220	43.8%	55	25.0%	34	15.5 %	71	32.3%	60	27.3%	73.5	3	0.000 *
Incinerator	15	3.0%	1	6.7%	3	20.0 %	3	20.0%	8	53.3%	1.5	3	0.692
Other resource recovery (biogas, composting)	5	1.0%	0	0.0%	1	20.0 %	3	60.0%	1	20.0%	2.8	3	0.418

* The Chi-square statistic is significant at the .05 level.

social science research, and the Chi-square statistic (64.738, $p < 0.000$) suggests that the model is statistically significant overall.

4 Discussion

Urban river systems frequently experience significant degradation, a condition prevalent not only in specific geographic regions but also universally in areas undergoing urbanization (Findlay & Taylor, 2006). This has resulted in urban river restoration initiatives Guimarães et al., (2021) focused on restoring river integrity to provide ecosystem services. Successful restoration efforts require understanding local residents' perceptions of the ecosystem services provided by urban rivers. Stakeholders tend to assign the greatest priorities to services most closely linked to their livelihood. Most respondents have a high priority on the provisioning services tightly linked to their sustenance and main sources of income (Zhang, Pang, et al., 2019). The results of this survey also revealed a good deal of consensus among the local residents regarding specific ecosystem services deemed important and unimportant, which could be informative when designing future management initiatives. Respondents placed a high value on the

provision of urban water supply 19.50%, water for livestock 14.70%, water for irrigation 12.00%, and a relatively low preferences for other ES such as cultural, regulating and supporting coincide with the findings reported by Meynell et al., (2021) for rivers in South East Asia.

In addition, stakeholders from one river to another displayed a clear difference in the appreciation for services that other stakeholders depended on. For example, the supply of domestic water from the Kikundi River (18.1%) was not perceived as the most important provisioning service compared to the residents located in the proximity of Ngerengere River (50.3%), Morogoro (22.8%) even though three-quarters of the sampled household falls within the midstream and downstream reaches of the Ngerengere River and its tributaries have some access to alternative sources of domestic water and other economic activities (Raphael et al., 2023).

The high preferences in the provisioning services and low level of relative importance assigned by local residents to the categories of supporting, regulating and cultural services as a whole, respectively, aligns with the results of other studies conducted in

developing countries (Notter et al., 2012; Rebelo et al., 2019; Khan et al., 2019). The low relative ranking of cultural services may not be synonymous with a perception of cultural services as having little value to stakeholders now or in the future because many cultural services are particularly difficult to assess (Burgess et al., 2016). In this study recreation values of Urban rivers were the most preferred cultural service especially for the residents of Mlimani ward. The high preference scores for recreational might be associated with their clear economic potential Nahuelhual et al., (2013) through tourism activities conducted in the upstream reaches of Uluguru Mountain (headwater). Key regulating services such as groundwater recharge were acknowledged by a significant proportion of respondents indicating the influence of river quantity and flow frequency on the lateral recharge of local aquifer systems (Chen et al., 2010; Visser et al., 2018). In the Ngerengere River, the role of urban rivers in promoting fish biodiversity and soil fertility was acknowledged as a key supporting service. The observation highlights the role of urban rivers in promoting urban agriculture development (Cook et al., 2015). According to literature, urban agriculture has the potential to address both short-term and long-term needs: it can increase food security and provide livelihood opportunities, while also helping to mitigate global climate change. Urban agriculture positively affects food security by addressing factors that limit access to food (Foeken & Mwangi, 2000).

The study revealed that the key threats to ecosystem services of Ngerengere River are informal sectors, urban farming, mismanagement of solid waste, industrial waste, urbanization and rapid population growth, domestic and industrial sewage, stormwater, automobile garages, atmospheric pollution that can cause surface water pollution due to air-water interactions. These threats to the ecosystem services of rivers are common in most developing countries (Tolo et al., 2012). These threats are attributed to the impact of urbanization and anthropogenic activities and directly affect provisioning, regulatory, cultural and supporting services hence resulting in low preferences by the residents (Jackson et al., 2016). The study revealed

that 12.4% of the residents stated the use of urban rivers for waste disposal including excreta and solid waste. Inefficiencies in an urban solid waste system can negatively impact drainage through increased maximum natural discharges and water quality degradation caused by street washing and the transport of solid material, which facilitates the introduction of foreign agents into the water resource's trophic chain and affects natural physicochemical processes (Salles et al., 2012). Changes in water quality due to mismanagement of waste impact various aspects of human well-being, with benefits and costs affecting different groups of beneficiaries across different spatial and temporal scales (Keeler et al., 2012).

Some studies have shown that individual characteristics such as gender, age, occupation, income, and education level had impacts on preferences (Asah et al., 2014; Tian et al., 2020). This study also proved this phenomenon. In this study, gender has a significant effect on preferences, which is similar to the study done by Yang et al., (2018) which cited that females and males usually derive different benefits from ES, therefore, their perceptions of ES also differ. Human cognition involves the active reflection of individuals on objects, shaped by both direct and indirect experiences. Generally, individuals with higher education levels possess a deeper understanding of provisioning, cultural, and regulating services and show a higher preference for these services (Bertram & Rehdanz, 2015). Our study reaffirmed this observation.

The survey results indicate that older individuals and those with longer residence times have a higher preference for ecosystem services due to their direct experiences. They have also observed environmental changes in urban rivers, leading to a higher preference for provisioning services. The difference in direct and indirect experiences of respondents regarding local environments explains why occupation significantly influences preference heterogeneity. Zhang, et al., (2019) research also demonstrates that direct experience and the local environment significantly shape people's understanding of their surroundings. Thus, personal factors impact preference

heterogeneity, which results from multiple factors. The low preferences for cultural, supporting, and regulatory services among residents of the study area might be associated with river pollution (Keeler et al., 2012). This finding aligns with Zhang et al., (2019) conclusion that while the importance of provisioning services is widely recognized, local residents have a relatively low awareness of the need for regulating and supporting services.

Over recent decades, various approaches have been developed to understand how riverine ecosystems function and how anthropogenic actions and developments such as pollution, river channelization, diversion, and damming can degrade their structure and functions. This understanding enables more effective management and protection of river ecosystems. A range of systems and frameworks for riverine ecosystem management have been created based on principles of biotic integrity, ecosystem health, and ecological resilience (Meynell et al., 2021). Therefore, water resource management frameworks should consider local residents' awareness of key issues related to water resource utilization and management (Böck et al., 2018). In this study, the level of local residents' awareness of key issues related to urban river management within the Morogoro Municipality indicated that most of the residents (68.3%) are very concerned with ecosystem services provided by rivers. The study identified that another issue is the high response related to ecosystem disservices of urban rivers in Morogoro Municipality reported by 85.5% of the local residents. The study revealed that the local residents are aware of river restoration techniques that can be conducted to leverage the ES desired from urban river and mitigate the anticipated disservices which are commonly related to human activities that have adversely affected the ecosystem of urban rivers (Guo et al., 2022). Surprisingly the study identified low awareness of local on policies and plans (22.1%) for river management and conservation as well as Acts, regulations and by-laws (37.3%). This observation highlights concerns regarding the strengths and weaknesses of policy and institutional frameworks in addressing pollution and the ecological status of

rivers, as well as their impacts on the biota (Awoke et al., 2016).

The results of our binary logistic regression analysis demonstrated significant variation in the coefficients associated with the socio-demographic factors influencing local residents' preferences for urban rivers. The distinct directions and magnitudes of these coefficients indicate that each factor contributes uniquely to shaping preferences, even in the presence of potential multicollinearity. For instance, the substantial odds ratio for individuals with over ten years of residence (10.581, $p < 0.001$) underscores the profound impact of long-term residency on preferences, suggesting that familiarity play a crucial role. Similarly, the notable associations observed for educational background—particularly for those with certificates (4.602, $p = 0.035$) and diplomas (4.568, $p = 0.055$)—highlight the influence of educational attainment on ES preferences. Conversely, the negative coefficients for larger household sizes (0.339 for 3-5 members, $p = 0.011$; 0.204 for 6-10 members, $p = 0.001$) indicate a declining likelihood of preference for urban rivers as household size increases, reflecting the potential complexities of social dynamics within larger families. These findings suggest that despite potential correlations among predictors, the model remains robust. The significant results provide a nuanced understanding of how socio-demographic factors shape residents' preferences for urban rivers, offering valuable insights for policymakers and urban planners aiming to engage communities in environmental initiatives. Our analysis indicated that socio-demographic characteristics significantly influence preferences for urban rivers. Future research should continue to explore these dynamics and we recommend explicit assessment of multicollinearity using methods such as Variance Inflation Factor (VIF) analysis for a more comprehensive evaluation, potentially incorporating additional variables to further elucidate the factors influence preferences of ES

4.1 Limitations of the Study

To ensure the sample accurately reflects the population's characteristics, we considered the urban

river network's drainage and socio-economic differences when selecting sample points, and then randomly distributed questionnaires at these locations. Although this method does not achieve complete randomness, it captures the diversity of residents' perceptions of ecosystem services across various natural and socio-economic contexts. While the randomness of this approach could be enhanced, it effectively represents the overall population. In future research, we will aim to more accurately capture local residents' perceptions of ecosystem services by increasing both the number of sample points and the sample size and using other economic methods to quantify the ecosystem services of urban rivers in the study area and other urban watershed of Tanzania.

5 Conclusion

Taking the urban watershed of Ngerengere River in Morogoro Municipality as an example, this study applies a social survey method to obtain data on residents' preferences and threats for ES of urban rivers. The results show that: Residents have a higher preference for provisioning services compared to other services such as regulating, supporting and cultural services. Residents' preferences for ES are heterogeneous, and residential factors and personal factors have an impact on heterogeneity. There are differences in residents' perceptions of ES in different rivers within the Municipality. The study highlights the significant influence of river health and integrity on local residents' preferences for ecosystem services (ES) provided by urban rivers. It identifies key threats to these services, including informal sectors, urban farming, mismanagement of solid waste, industrial waste, urbanization, rapid population growth, domestic and industrial sewage, stormwater, automobile garages, and atmospheric pollution. These threats stem from urbanization and human activities, adversely affecting regulatory, cultural, and supporting services, which in turn lowers residents' preferences for these ecosystem services.

Despite many policies and legal frameworks, there is still more work to be done on the urban catchment of Ngerengere. The catchment lacks access to good sanitation as it is currently dominated by onsite

sanitation practices and the absence of a well-engineered sanitary landfill for solid waste disposal. The aforementioned threat along with urban farming practices calls for implementable actions to enable the management of agriculture and fertilizer usage more efficiently. As urban farming remains important for the livelihoods of residents and is usually considered in integrated urban activities, planners should consider and recognize the potential of urban farming in building sustainable and dignified urban areas without compromising the integrity of the riparian land which is important for healthy aquatic environments. Regarding urban river management, the study reveals that a majority of local residents are aware of and concerned about the ecosystem services provided by urban rivers.

Additionally, a significant proportion of residents recognize the ecosystem disservices associated with urban rivers in Morogoro Municipality. There is also awareness among residents about river restoration techniques to enhance desired ES and mitigate disservices. However, there is a notable lack of awareness about policies, plans, and regulatory frameworks for river management and conservation. The study recommends that improving ES of the urban watershed Ngerengere River should be carried out in the following aspects: controlling the major threats of ES to urban rivers such as pollution from sanitation systems, industrial effluents, solid waste management and agricultural activities, raising residents' awareness of other ecosystem services of the river, and restoration initiatives. Therefore, when establishing plans and initiatives for urban river management, it is essential to clearly understand the residents' perceptions of ES, which will be beneficial for the sustainable use of ES.

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