UNIVERSITY OF NOVI SAD

FACULTY OF AGRICULTURE

Department of Water Management

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Bachelor of Agriculture

WATER FOOTPRINT OF URBAN AGRARIAN HOUSEHOLDS FROM SOUTHERN NIGERIA

MASTER'S THESIS

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Vodni otisak urbanih poljoprivrednih domaćinstava u južnoj Nigeriji

Sažetak

Cilj ovog master rada je analizirati ukupni vodni otisak poljoprivrednih domaćinstava i njegove komponente te identifikovati aktivnosti sa visokom potrošnjom vode u urbanim i ruralnim poljoprivrednim domaćinstvima u južnoj Nigeriji, koristeći državu Enugu kao studiju slučaja. Višestepenmi postupkom izabrana su 64 domaćinstva za anketiranje: 33 urbana i 31 ruralno domaćinstvo. GIS alati (QGIS) su korišćeni za mapiranje izabrane lokacije studije slučaja. Podaci su prikupljeni putem polustrukturisanih upitnika i analizirani korišćenjem deskriptivne statistike, Vesterove matrice i regresije najmanjih kvadrata koristeći IBM SPSS softver. Ukupni vodni otisak urbanih poljoprivrednih domaćinstava (19,516.9 m^3 mesečno) bio je za 6.6% veći od onog kod ruralnih domaćinstava (17,088.2 m^3 mesečno). Veličina poljoprivrednog zemljišta identifikovana je kao socioekonomska promenljiva koja je značajno uticala na ukupni vodni otisak i urbanih i ruralnih poljoprivrednih domaćinstava. Na osnovu Vesterovih matrica, kao ključni problemi koji uzrokuju visoku potrošnju vode prepoznati su: neracionalna upotreba vode u urbanim domaćinstvima i nedostatak uređaja za štednju vode u ruralnim domaćinstvima.

Ključne reči: vodeni otisak, potrošnja vode, poljoprivreda, urbano, ruralno, domaćinstvo

Water Footprint of Urban Agrarian Households in Southern Nigeria

Summary

The aim of the master thesis is to analyze the total water footprint of agricultural households and its components and identify high water consumption activities in urban and rural farming households in Southeast Nigeria, using Enugu State as a case study. A multistage sampling procedure selected 64 participants (33 urban and 31 rural households). GIS tools (QGIS) were used to map the study location. Data was collected through semi-structured questionnaires and analyzed using descriptive statistics, the Vester matrix, and Ordinary Least Squares regression with IBM SPSS software. The total water footprint of urban agricultural households (19,516.9 m^3 per month) was 6.6% higher than that of rural households (17,088.2 m^3 per month). Farmland size was the socioeconomic variable that significantly influenced the total water footprint of both urban and rural agricultural households. Critical issues related to high water consumption included irrational water use in urban households and a lack of water-saving devices in rural households.

Key words: water footprint, water consumption, agriculture, urban, rural, household

1. INTRODUCTION

The goal of the research is to estimate the total water footprint of agricultural households and identify activities associated with high intra-household water consumption in the context of urban and rural farming homes in Southeast Nigeria, using Enugu State as a case study. The problem is that Nigeria is currently experiencing one of the most significant urban transformations in recorded history. Nigeria's urban population has increased by about 62.5 million people since gaining independence in 1960, and projections for 2050 indicate that this number will rise to 226 million (United Nations, 2014), with the majority of the urban growth in the Southern part. With water sources under increasing strain due to industrialization, population growth, and climate change impacts, understanding the water footprint of urban agricultural households becomes paramount. Nigerian urban areas are experiencing climate-induced food insecurity and poverty due to the over-reliance of cities on rural food supplies (Mohammed & Charles, 2016), as well as the continuous depopulation of rural areas, and persistent growth in urban populations (WFP, 2016). The rapid urbanization and high food demand in Southern Nigeria have triggered a notable shift in household dynamics, with an increasing number of urban and peri-urban residents turning towards agriculture as a means of supplementing their food supply and bolstering local resilience. This urban agrarian movement encompasses a diverse array of activities, ranging from greenhouse and container farming to backyard poultry keeping and fishpond cultivation.

Urban agriculture is an evolving concept. It means cultivating soil, growing crops, and raising livestock in intra-urban (within the city) and peri-urban (on the outskirts of the city) spaces. The 2018 Farm Bill refers to the demographic engaged in urban farming as those involved in urban, indoor, hydroponics, and aquaponics, rooftops and other emerging agricultural production (United State Department of Agriculture, USDA). Shreds of scientific literature have confirmed the multiple socioeconomic and environmental benefits of urban agriculture, including contributions to food and nutrition security, ecosystem service provisions, livelihood improvement, unemployment, natural resource conservation, pollution reduction, and urban beautification (Opitz et al., 2016; Specht et al., 2014; Orsini et al. 2013; de Bon et al. 2010; Barthel and Isendahl, 2013; Costello et al., 2021). Urban agriculture is considered an effective strategy to mitigate climate change because it could reduce greenhouse gas emissions by shortening the food supply chain and decreasing the food quantity and quality losses caused by long-distance transportation (Aubry and Kebir, 2013). And help in strengthening urban food system resilience to pandemic situations like the COVID-19 lockdown restrictions (Langemeyer et al., 2021). Despite the multi-functional benefits, urban farmers in developing countries face significant challenges related to land, water, infrastructure, contamination, lack of support, and limited access to resources and services (Orsini et al., 2013).

Agriculture accounts for over 70% of global freshwater consumption with 75 countries – including Nigeria, falling below 50% water use efficiency rates, resulting in the irresponsible utilization of available water resources (International Institute for Sustainable Development (IISD), 2018; International Atomic Energy Agency (IAEA), 2023). Urban farming significantly contributes to water usage, especially when irrigation is involved. A study by the International Water Management Institute (IWMI) found that within cities alone, there are about 24 million hectares of land under irrigation, and 44 million hectares that are rain-fed (Consultative Group for International Agricultural Research). A number larger than the total cultivated area under maize in sub-Saharan Africa. This scale of irrigation and also use of polluted water for irrigation can have a substantial impact on water resources, particularly in areas where water is already scarce. There remains a dearth of research examining the quantitative and qualitative dimensions of the total volume of fresh water used for the goods and services produced by agricultural households in urban and rural households in Nigeria. This knowledge gap impedes the formulation of actionable policies and interventions aimed at reconciling the increasing demand for water with the imperative of preserving water quality and availability for future generations, and explorations of intra-national virtual water trade opportunities. Integrating the water footprint concept into sustainable agricultural development can improve water efficiency, conserve water, and reduce environmental impacts (Ray, McInnes and Sanderson, 2018; Alexoaei, Cojanu and Coman, 2021; Jhilam et al., 2023), and influence local food prices through virtual water trade.

1.1 CONCEPT OF WATER FOOTPRINT (WF)

The concept of WF has rapidly become a vital tool for understanding and managing water use. It is a consumption-based indicator that measures the total volume of freshwater used directly and indirectly by a nation, company, or in the provision of a product or service. This idea of considering water use along supply chains was introduced by a Dutch academic, Arjen Hoekstra in 2002, along with the other parameters: environmental and carbon footprints (Hoekstra, 2002). These are all indicators of individual and collective environmental impact, ranging from the more general environmental footprint to the more specific water and carbon footprints, which measure water consumption and carbon dioxide emissions, respectively. As of the time of conception, the WF concept was not novel. In 1993, British geographer, John Anthony Allan coined the term "virtual water" to refer to the "hidden" or non-visible water used in the production of food and other commodities (Enel Group, 2022). It was used to depict all the freshwater that is consumed or transformed in order to produce commodities or services at their point of origin, and which is then traded across international lines embedded in these commodities or services (Stack and Whitney, 2018). Virtual water offers a way to quantify water and move it across international boundaries by allowing water-scarce countries to effectively import freshwater through trade in commodities (Stack and Whitney, 2018). Hoekstra extended Allan's theory to include both direct consumptions, i.e., water consumed by a person, company, or country, and indirect consumption, which includes the sum of the water footprint of all products consumed.

According to Hoekstra (2016) the WF of a product is the sum of the WFs of the process steps taken to produce the product. For a business, the WF is the sum of the WFs of the final products produced by the business, which includes the operational WF of the business as well as its supply-chain WF. For consumers, it is the sum of the WFs of all products consumed. For nations, it is the sum of the WFs of the country's inhabitants, which includes an internal component (the WF within the national territory for making products that are consumed within the country) and an external component (the WF in other countries for making products imported by and consumed within the country considered). The total WF within a certain area (e.g. a municipality, province or state, or a hydrological unit like a catchment area) is the sum of the WFs of all processes taking place within the area. Regardless of the scope of application, total WF is composed of three components: green, blue, and grey. Green WF refers to water from precipitation that is stored in the root zone of the soil and transpired or incorporated by plants – insofar as it does not become run-off (Hoekstra, 2011). Blue WF is water that has been sourced from surface or groundwater resources and is either evaporated or incorporated into a product. Grey WF refers to the amount of freshwater needed to dilute or assimilate the load of pollutants given natural background concentrations and existing ambient water quality standards (Hoekstra, 2011), which is an idea that builds on the concept of dilution water requirement earlier applied by Postel et al. in 1996. The water footprint concept has been applied in various sectors, including agriculture, to assess the sustainability, efficiency, and equitability of water use.

Over the last decade, methodological advances have included the development of the four-step Water Footprint Assessment (WFA) which includes setting the scope of analysis, water accounting, sustainability assessment, and response formulation (Hoekstra et al., 2009, Hoekstra et al., 2011). WFA starts with setting the goals and scope of the water footprint study which could directed to support businesses, governments, and regulatory agencies on national/regional to sustainable water allocations and management. The goal of WFA can be directed towards scaling awareness on water sustainability issues related to water use and defining benchmarks for volumetric water consumption and water pollution for a specific sector of activity or production of a specific product. This is followed by water footprint accounting which requires data from global databases, such as WaterStat, or collected locally. The calculations for the green, blue and grey water footprint follow the methodology described in the Water Footprint Assessment Manual (WFAM) (Hoekstra et al., 2011). The sustainability assessment step requires assessing whether water use is balancing the needs of people and nature if limited water resources are being used to the greatest benefit and how fairly water use is shared. Using the information gained in the accounting and sustainability assessment steps of WFA, response strategies that reduce the water footprint and improve its sustainability can be prioritized for implementation (Hoekstra et al., 2011). WFA is a multidimensional indicator that aids in developing strategies, policies, and remedial measures for sustainable water use and resource management, crucial for social, economic, and environmental well-being.

According to the Water Footprint Network the variables such as type of food, total volume of drinking water consumed, form of water consumption (Green, Blue, Gray), place of production and other parameters such as the water used in all phases of production, including cultivation, processing, and transportation are important in accounting the WFs, which is expressed as volume of water per unit of product or as a volume of water per unit of time (https://www.waterfootprint.org). Other metrics focus on virtual water, which refers to the water embedded in the production and trade of agricultural products (Vallino, Ridolfi & Laio, 2021). Water footprint modeling plays a crucial role in understanding water usage and pollution levels, aiding in sustainable water management and development (Mehla et al., 2023; Mehla, 2022). It helps identify vulnerabilities, improve water productivity, and promote sustainable water use in various sectors, especially agriculture (Nydrioti et al., 2023). The water footprint simple and effective tool that enables the assessment of green, blue, and gray water components, essential for evaluating water availability and accessibility for agricultural production. Performing water footprint assessment in different regions and agricultural sectors will provide valuable insights into the impacts and limitations of current production systems, guiding the implementation of suitable actions to combat water scarcity challenges and enhance water security.

1.2 SOCIAL AND ECONOMIC DRIVERS OF WATER USAGE PATTERNS IN URBAN AGRARIAN HOUSEHOLDS

Water usage patterns in urban agrarian households are influenced by a variety of social and economic factors (Avazdahandeh and Khalilian, 2021; Huang et al., 2023; Abu-Bakar et al., 2023). In a study conducted in China, rapid socioeconomic transitions influenced urban household water use, with changes in economic development patterns and urbanization processes impacting water consumption levels (Zhang et al., 2020). The results from the study showed that China's urban water use has increased by 58 billion m3 during 2002–2012, and then decreased by 13 billion m3 during 2012–2017 due to the above-mentioned factors. Water use efficiency gains and economic structural improvements effectively offset the increase in water use, which is driven by the rising final demand level and growing population. The household water footprint has been found to increase due to urbanization and changing consumption patterns, with technological levels, consumption patterns, and population identified as key driving factors (Li et al., 2022). Furthermore, household water consumption trends in urban areas are influenced by factors such as income levels, household size, education levels, and awareness of water costs and quality (Narmilan et al., 2021).

In a study of socioeconomic determinants influencing levels of water consumption in the urbanized medium-sized city in Singapore, the authors found that at a 95 percent confidence level, the age of the head of household, total monthly income, housing type, the number of water source utilized by every household, the total number of people in every household, and total person work in every household simultaneously determining water consumption of households in the study area. With socioeconomic variables explaining 16 percent of the whole factors determining household water consumption (Rahayu and Fitria, 2019). In furtherance, a study was conducted in Nekemate town, East Wollega Zone of Ethiopia (Ali & Terfa, 2012), with the objective of describing the determinant factors that affect the consumption of water at the household-level. Residents of the town used daily per capita water 15.26 liters for different domestic activities, which was three times lower that IWRA standard that spatially and temporally varies at the household level. The study found that the level of income, employment and education influence the consumption of water, with females used more water, and due to the economic backwardness of the study area. This is in line with studies conducted in Southern Nigeria (Adewole, Ayoade and Oladapo, 2021; Olawuyi and Mushunje, 2019; Istifanus, 2017) showing that socio-economic factors influence such as price, gender, occupation, water source, religion, household size, education, income level determines water usage in urban agrarian households. Understanding these social and economic drivers is essential for developing effective strategies to promote sustainable water usage in urban agrarian households in Nigeria.

1.3 CONSEQUENCE OF URBAN AGRICULTURE ON LOCAL WATER RESOURCES

Urban agriculture plays a crucial role in the sustainability of Food, Water, and Energy resource flows within urban areas, which is an emerging field of study (Rathore et al., 2023). The expansion of urban areas due to factors like population growth and economic development leads to increased pressure on available water resources, affecting both household agricultural and water consumption (Huang et al., 2023). Additionally, multidimensional urbanization, including population, economy, spatial distribution, and society aspects, impacts the water footprint self-sufficiency rate of staple crops, influencing the balance between water supply and demand in agricultural regions (Qiu et al., 2023). Furthermore, the spatial agglomeration of agricultural populations in urban areas can influence agricultural water supply internalization, highlighting the interconnectedness of urban and agricultural water systems (Avazdahandeh and Khalilian, 2021).

On the other hand, urban agriculture offers numerous advantages to the water sector, such as improving rainwater harvesting and the reclamation of stormwater and treated wastewater, often referred to as water for food. These alternative water sources are particularly significant in certain areas, like dry and arid regions, where they can complement traditional irrigation methods (Qiu et al., 2023). Moreover, urban agriculture can decrease the overall demand for irrigation through techniques like targeted or smart irrigation, which are more efficient compared to conventional agricultural practices like irrigated cropping systems (Daigger et al. 2015). Furthermore, large-scale urban agriculture can reduce the need for virtual water imports—the water used to produce imported food products—by enhancing local food production. This practice also improves water infiltration and recharge, helping water penetrate the soil and replenish aquifers, reduces runoff, and ultimately helps to restore groundwater levels (food for water). Additionally, urban agriculture provides essential ecosystem services on both local and global scales, including enhancing the microclimate, sequestering carbon, managing surface runoff, and supporting biodiversity (Deelstra and Girardet 2000; Lovell and Taylor 2013; Gondhalekar and Ramsauer, 2016).

1.4 IMPORTANCE OF MINIMIZING THE WATER FOOTPRINT IN AGRICULTURAL HOUSEHOLDS

Decreasing the WF of agricultural households is crucial for significant socio-economic benefits by enhancing water productivity, maximizing crop yield and reducing pollution. Implementing water-efficient practices can lead to cost savings and increased efficiency in water use, necessary to ensure that crops are grown using the available water resources, thereby maintaining food security, reducing water waste and reducing the risk of water scarcity impacting food production (Mehla et al., 2023; Dobrescu et al., 2020). Yu et al. (2019) noted that urban residents have a higher WF for food consumption compared to rural residents, highlighting the necessity for efficient water management strategies in urban areas. Therefore, reducing the WF helps conserve water resources, which are increasingly under pressure due to growing demands from various sectors (Mekonnen and Hoekstra, 2013; Mehla et al., 2023; Dobrescu et al., 2020). Studies have shown that urban agriculture, through models like CityCrop, can reduce water requirements by up to 17% compared to traditional grass lawns, allowing for localized production of vegetables and potentially reducing water demand if watering restrictions apply only to lawns (Mark et al., 2015). The CityCrop is a plant growth and evapotranspiration model that couples a 3D model of tree canopies and buildings derived from LiDAR with a ray-casting approach to estimate spatially explicit solar inputs in combination with local climate data (Mark et al., 2015). Furthermore, a focus on precision water management in crop production, especially in moisture-stressed areas, is crucial for sustainable water use, with practices like sensor-based micro-irrigation techniques and conservation agriculture playing a key role in reducing water footprints and improving water resource management (Deng, 2014). Moreover, a study in China emphasized the importance of balancing water consumption and economic value creation in crop production, highlighting the need for regional coordination and rational crop price regulation to optimize economic benefits while minimizing water footprints in agriculture (Singh et al., 2022).

The WF assessment helps in creating policies and practices, ensuring that water is allocated efficiently and sustainably across different production processes thereby minimizing water pollution by reducing the grey water footprint – essential for maintaining ecosystem health and preventing environmental degradation (Mehla et al., 2023; Mekonnen and Hoekstra, 2013). Furthermore, the reduction of agricultural water consumption and pollution, through sustainable practices can contribute to mitigating the impacts of climate change, such as droughts and floods, and help boost localized food resilience in both urban and rural areas (Mehla et al., 2023; Dobrescu et al., 2020). Implementing measures that promote a less water-intensive activities in households and improve overall agricultural efficiency, is crucial to mitigate the growth of the WF among urban and rural residence, ensuring sustainable water resource management for future generations.

2. TASK AND OBJECTIVE

The goal of the research is to estimate the total water footprint and its components and identify activities associated with high intra-household water consumption in the context of urban and rural agricultural households using Enugu State as a case example for Southern Nigeria. It also seeks to examine the relationship between green, gray, and blue water consumption and the socio-economic factors that influence the total water footprint and its components. With the increasing effects of climate change and detected growth of urban agricultural production in Southern Nigeria, increased pressure on water resources is expected in the future and reducing this pressure requires analysis of, currently missing, data on water use. Task of this thesis is :

- Creating a questionnaire including questions on green, blue, and gray water footprint and activities associated with high intra-household water consumption.
- Training of field survey enumerators on how to schedule an interview and administer the study questionnaire to the respondents.
- Surveying of different study participants by the survey enumerators.
- Comparing of resulting characteristics of urban and rural agricultural households water use using charts and other data visualization techniques.
- Defining recommendations for households and agricultural production aspects that require water-saving technologies.

Obtained results will, expectedly, enable defining actionable policies and strategies for sustainable water resource management and prioritizing areas where water-saving innovations and technologies are needed in the study location.

3. MATERIAL AND METHODS

3.1 STUDY AREA

The Southeast region of Nigeria is situated between latitudes 04° 30'N and 07° 30'N and longitudes 06° 45'E and 08° 45'E, encompassing the states of Abia, Anambra, Ebonyi, Enugu, and Imo (Figure 1). The Southeast region spans a total land area of 10,952,400 hectares and has a population of 16,381,729 people (National Population Commission (NPC), 2006). Geographically, Southeast Nigeria is characterized by a tropical rainforest climate with a distinct wet season from April to October and a dry season from November to March. The dry season typically lasts for 4–5 months, with the highest rainfall occurring from July to October, with a slight respite in August (Okoronkwo et al., 2024). The region's terrain features rolling hills, dense forests, well-drained soils, featuring prominent rivers such as the Niger, Imo, Anambra, Idemili, Njaba, Nkisi, Ezu, and Oji, as well as notable lakes like Nike Lake and Oguta Lake (Ibeje, 2021), with major rivers such as the Niger, which forms the western boundary, and others like the Imo, Anambra, and Cross River, providing vital water resources. The region experiences an average annual rainfall of approximately 1,952 mm, with mean daily and annual temperatures of about 28°C and 27°C, respectively (Igbokwe et al., 2008). This region is predominantly agricultural, featuring sandy, often loose and porous soils. The main crops cultivated include cassava, rice, yam, cocoyam, maize, plantain/banana, cashew, oil palm, and coconut. Major livestock in the area comprises goats, sheep, and poultry. The effects of climate change are evident in the Southeast, with increasing incidents of flooding, landslides, and erosion. These events have led to the loss of lives, homes, farmlands, properties, and roads, among other adverse impacts (Agwu and Okhimamhe, 2009).

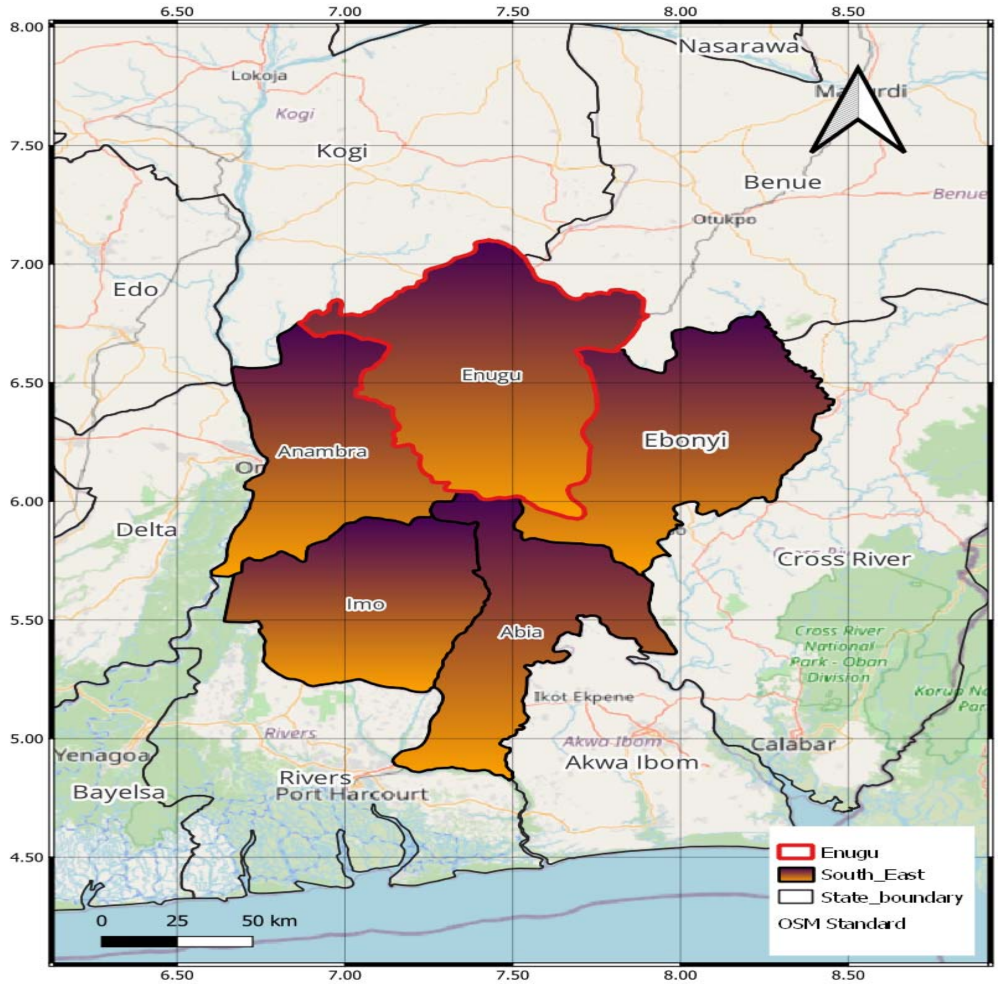

Figure 1 Map of Southeast Nigeria

Geospatial Data Source: ESRI Imagery. GRID3 Nigeria, Open Street map. Software Quantum GIS 3.28.0-Firenze

Despite its rich water resources, Southeast Nigeria faces significant water-related challenges, particularly in its agricultural settings. Water availability for agriculture is inconsistent due to seasonal variability. The distinct wet and dry seasons lead to fluctuations in water supply, with the dry season often resulting in water scarcity that impacts irrigation and crop production (United States Agency for International Development (USAID), 2021; Adeoti et al., 2023). Many rural areas lack adequate irrigation infrastructure and rely heavily on rain-fed agriculture, making them vulnerable to changes in rainfall patterns. The water infrastructure in Southeast Nigeria is inadequate and unreliable, with high rates of failed water projects and non-operational water supply systems (Adeoti et al., 2023; Vanguard, 2021). Thereby compound water scarcity issues and limited access to water for agricultural use. Agricultural runoff, resulting from the use of Nitogen and Phosphorus fertilizers and pesticides, contaminates rivers and streams, harming aquatic life and reducing the quality of water available for irrigation (Okorafor et al., 2017). Additionally, industrial pollution, particularly from small-scale industries with improper waste disposal practices, exacerbates the contamination of water sources (USAID, 2021). Heavy rainfall and poor land management practices lead to soil erosion, which degrades agricultural land and silts water bodies, reducing their capacity to support irrigation. Gully erosion is especially severe in areas like Anambra and Enugu, where it destroys farmland and disrupts local hydrology, making water management more challenging for farmers (Okorafor et al., 2017; Okenmuo, Ibeh and Obalum, 2023). The case example for this present study was conducted in the urbanized and rural part of Enugu State, which will be used a model for riparian states in the entire southeast region (Figure 2).

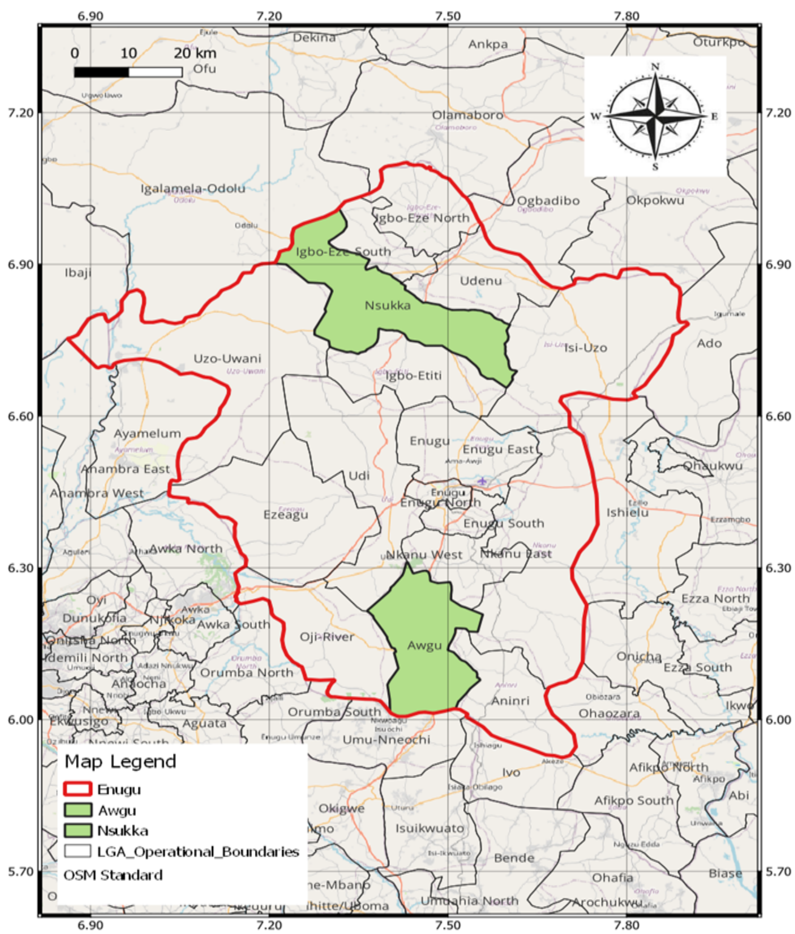

Figure 2 Map of Enugu State, Nigeria

Geospatial Data Source: ESRI Imagery. GRID3 Nigeria, Open Street map. Software Quantum GIS 3.28.0-Firenze

3.2 CRITERIA FOR CLASSIFICATION OF URBAN AND RURAL CENTRES

In the context of this research, it is crucial to establish clear criteria for distinguishing between respondents from rural and urban centers to ensure the accuracy and relevance of the collected data. The classification is based on multiple factors, including geographic location, population size, economic activities, infrastructure and amenities, and administrative definitions. Geographically, urban centers are defined as areas within the boundaries of a city or town. These locations are characterized by a high population density and the presence of substantial infrastructure, such as residential areas, commercial districts, and public services. In contrast, rural areas are situated outside the limits of cities or towns, marked by lower population densities, extensive agricultural activities, and limited infrastructure. Additionally, the administrative definition provided by national or local governments is considered. Areas classified as urban or rural by these authorities based on administrative boundaries form part of the criteria used in this research.

3.3 POPULATION AND SAMPLING PROCEDURE

The population of the study comprises all small, medium and large-scale crop and livestock farming households in Enugu state. A multistage sampling technique was used for the selection of the population sample (respondents) of the study. The multistage sampling procedure for the selection of respondents was as follows:

At the first stage, a list of rural areas (including Agbani, Lejja, Obimo, Nguru, Umakashi, Edem ani and Ehalumona) and urban areas (including Ugwuoye, Ugwuachara, Orba road, Onuiyi, Barracks, Odenigbo, Odenigwe, Odim, Enugu Road, Aku road, Obechara and Isiakpu) was compiled using the abovementioned criteria. Serial numbers were assigned to each location, and a table of random numbers was used to select locations including Obimo, Nguru, Lejja, for rural areas and Isiakpu, Odim, Ugwuachara, Odenigbo and Agwu for urban centers.

At the second stage, purposive, accidental and snowballing sampling technique was used to compile a list of 16 farming households from each study district to give a total of 128 households – each household was assigned a serial number based on their respective location. At the third stage, the simple random technique was used to select 31 rural and 33 urban farming household heads from the list. The sample size was determined using simple random probability sampling, ensuring that every individual in the population had an equal chance of being selected. Therefore, the total sample size for the study was sixty-four (64).

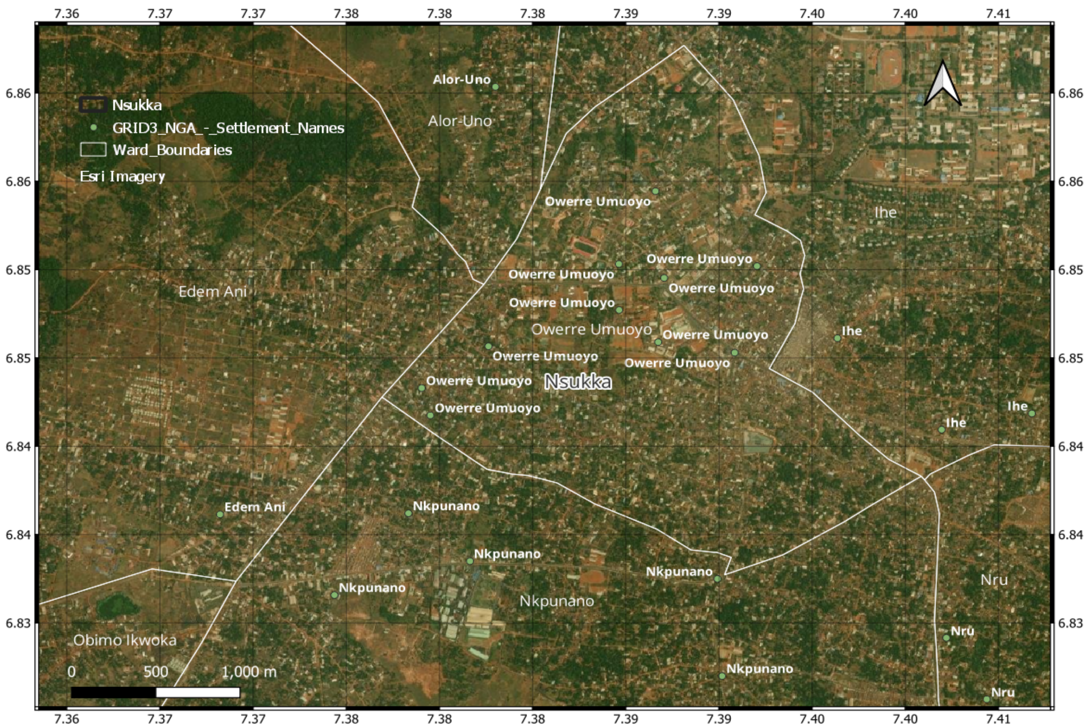

Figure 3 Satellite imagery of Nsukka, Enugu State, Nigeria

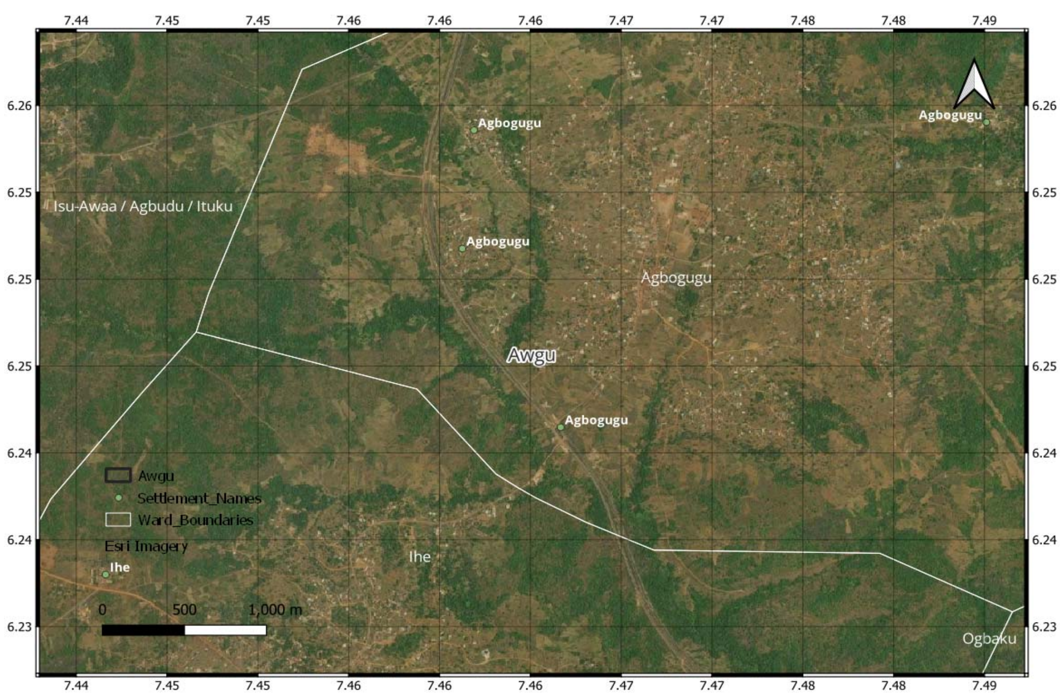

Figure 4 Satellite imagery of Awgu, Enugu State, Nigeria

3.4 INSTRUMENT FOR DATA COLLECTION

A face-to-face interview schedule (Figure 5) was employed for data collection, utilizing a questionnaire initially designed by García and Toro (2013) for evaluating the Water Footprint Generated by the Commercial and Residential Sectors of the La Florida Neighbourhood (Bogotá D.C.). Parra-Orobio et al. (2023) later enhanced this instrument to assess the water footprint in low-income urban neighborhoods of Fátima (Gamarra, Colombia), with validation by water resources experts from Universidad Popular del Cesar – Aguachica (Colombia). The revised questionnaire included both closed and open questions. For this study, the questionnaire was further adapted to the context of agricultural households by incorporating questions about volumetric water consumption in farming activities. While also observing the rain water harvesting and storage techniques of the study participants (Figure 6). The household survey, prepared following the recommendations of the aforementioned authors, consisted of 44 questions (open and multiple-choice), divided into two sections: (i) socioeconomic aspects and (ii) intra-household water consumption. This instrument was further subjected to content, structure and face validity, through the help of research experts from the Department of Water Management at the University of Novi Sad, Serbia and the Hungarian University of Agriculture and Life Sciences. The ethical approval for the instrument to be applied in the study district was obtained through a research contact person at the Department of Agricultural Extension, University of Nigeria, Nsukka. Study participants were granted informed consent before answering the questionnaire. Surveys were conducted from 2nd -20th of June 2024.

Figure 5 Sample pictures of field enumerators

Figure 6 Sample picture of rain water havesting and storage in the study location

3.5 MEASUREMENT OF VARIABLES

The socio-economic characteristics of the respondents were measured and operationalized as follows:

Water Source: Respondents were asked to indicate their sources of water including well, rainwater, community stream, borehole and river.

Size of household: Respondents were asked to specify the number of people living in the same house and eating from the same pot.

Adults: Respondents were asked to specify the number of adults living in the same house and eating from the same pot.

Children: Respondents were asked to specify the number of children living in the same house and eating from the same pot.

Educational level: Respondents were asked to indicate their level of education, which was later categorized as: no formal education, primary education, secondary education and tertiary education.

Years of experience in farming: Respondents were asked to indicate the number of years they had been working as a farmer.

Objective one was designed to estimate the total water footprint of agricultural households which comprises of green, blue and gray water footprints. The first section included questions regarding the socioeconomic characteristics (mentioned above), and food consumption patterns (due to indirect water use associated with food consumption). The second section enquired about personal hygiene, and household cleaning water use. The third section entailed questions on agricultural water use including farm equipment washing, irrigation, and livestock water consumption (See appendix: Annex B).

3.5.1 Water footprint estimation

The study estimates the three components of the WF: WF_{blue}, WF_{gray}, and WF_{green}, and develops a systematic tool for WF estimation following Parra-Orobio et al. (2023) recommendation. In this context, WF_{blue} was determined using volumetric data of water used for drinking and cooking, collected through a household survey (Equation (1)).

$$WF_{blue} = V * month \quad \text{……………………….(1)}$$

Here, WF_{blue} represents the Blue Water Footprint (L/month), V denotes the daily water usage for drinking and cooking, and the month is considered as 30 days.

For the WF_{gray} calculation, typical daily activities such as showering, brushing teeth, and washing dishes, among others, were assessed (Equation (2)).

$$WF_{gray} = F_{act} * V_{act} * Inhab * month \quad \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where WF_{gray} represents the Gray Water Footprint (L/month), F_{act} is the daily frequency of the activity, Inhab is the number of people that develop the activity, and a month is equivalent to 30 days.

In this study, the WF_{green} was calculated using data on the family's product purchases for their basket, acquired at specific intervals (daily, weekly, or monthly).

$$WF_{green} = Q_p * WF_{foodi} * month \quad \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

WF_{green} stands for the Green Water Footprint (L/month), Qp is the quantity of vegetable or animal products purchased weekly (measured in kg or L), WF_{foodi} represents the estimated volume of water consumption of product i (either vegetable or animal food) (measured in L), and the month is equivalent to four weeks.

Finally, the total water footprint (WF_{total}) is the sum of WF_{blue}, WF_{green}, and WF_{gray}.

$$WF_{total} = WF_{blue} + WF_{green} + WF_{gray}$$

Objective two was designed to determine the household activities associated with high water consumption. A Vester matrix was developed to identify and analyze both direct and indirect causes, effects, and central issues exerting pressure on water resources (Leiva and Álvarez, 2021). Respondents were provided with a list of real problems in the community with a group of experts (knowledgeable about the problem). Problems such as leaving the tap running when taking a shower, brushing of teeth, using large amount of water to reduce dust in the street, among others, were presented to the respondents. A five-point Likert-type scale was used, and respondents were requested to tick strongly agree (SA=5), agree (A=4), neutral (N=3) disagree (D=2) or strongly disagree (SD=1) against each response option in order to indicate their activities that causes high water use in households. The mean of the responses were calculated, mean above 3.0 used to choose the most representative problems, defining them in the best possible way. A Vester matrix is assembled, where each problem is confronted with the others, determining with the group of experts, the degree to which each problem is a cause of the other, for which the problem of the chosen row is related to other problems that are in the columns, using the following question. Is the problem (row 1) related to the problem (column 1). According to the validity of said statement based on the interdependency of problems on a scale from 0 to 3, the following score were assigned: there is no relationship between the two problems (0), the relationship is very indirect or not very obvious (1), the relationship is fairly direct (2), the relationship is direct (3). By determining causes and effects and positioning them on a Cartesian plane, the matrix prioritizes problems. Each problem is then classified as passive, critical, indifferent, or active and placed on the plane based on the sum of the rows (causal influence (X)) and columns (dependency (Y)) (Leiva and Álvarez, 2021).

Hypothesis one was tested using linear regression model. The independent variables were the socio-economic characteristics of the respondents while the dependent variable was the total water footprint of agricultural households. Categorical variables such as educational level was dummy coded to transform them into dichotomous variables. The continuous variables such as household size, number of adults, number of children, years of farming, size of farmland and number of livestock were directly entered into the regression model. The regression equation includes the following:

$$Y=\alpha + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \beta 5X5 + \beta 6X6 + \beta 7X7 + U \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

Where:

Y= total water footprint of agricultural households

β = regression coefficient

X1 = educational level (formal education = 1, no formal education = 0)

X2 = household size,

X3 = number of adults,

X4 = number of children,

X5 = years of farming,

X6 = size of farmland

X7 = livestock ownership

U = stochastic error term

3.6 Data analysis

Data was processed using descriptive statistics (frequency, percentage, and mean score) and inferential statistical methods. The hypotheses of the study was tested using Pearson's correlation and ordinary least squares regression analysis. Analysis was performed using Microsoft Excel and IBM SPSS statistical software.

4. RESULTS AND DISCUSSIONS

4.1 SOCIOECONOMIC CHARACTERISTICS OF THE STUDY PARTICIPANTS

Figure 7 shows that the majority (71.9%) of the respondents' source water from boreholes and water tankers, while about 67.2% depend on rainwater harvesting. This implies that both rural and urban rely on artificial or managed water sources. Additionally, the reliance on rainwater harvesting indicates a conscious effort to utilize natural resources and mitigate water scarcity among households. Other sources of household water include wells (42.2%), community streams (23.4%), and rivers (1.6%). A smaller percentage of respondents rely on community streams and rivers, possibly due to their limited availability, accessibility, safety and reliability as water sources.

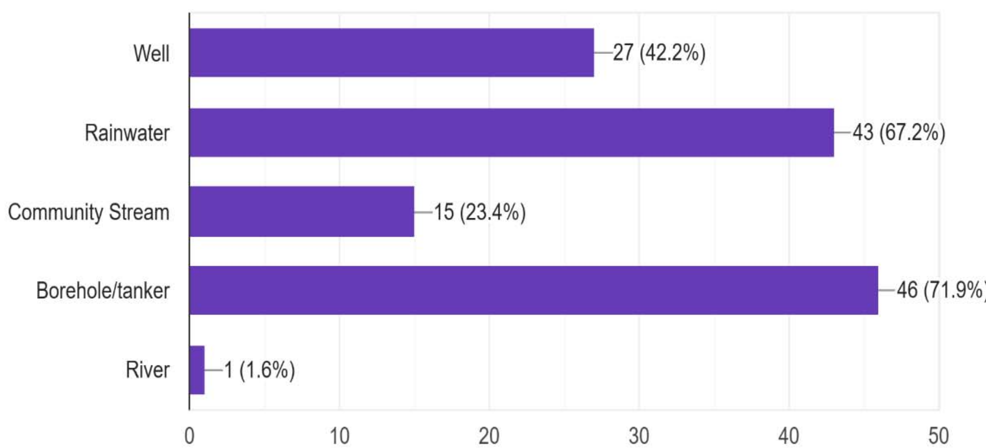

Figure 7 Distribution of household water sources

Results in Table 1 show that the mean household size of urban (x̄ = 5.6) and rural (x̄ = 5.8) participants is approximately 6 people per household. This aligns with the findings of Okoronkwo et al. (2024) who posited that the mean household size in southeast Nigeria is 6. These household sizes in the region contribute to a valuable pool of labour for agricultural activities. Findings showed that the majority (48.5%) of the urban participants attended tertiary education while the majority (34.4%) of the rural participants had no formal education. This implies that rural people have relatively lesser assess to formal education which could impact their ability to decode information related to sustainable water management. Also, results in Table 1 showed that both rural and urban respondents had mean years of farming experience of more than 10 years while rural household cultivates approximately 3 hectares of land compared to urban household that cultivates less than 1 hectare of land. This aligns with the findings of Birhanu (2023) who noted that the demand for urban land for residential, commercial, and industrial purposes has led to smaller available plots for agriculture, impacting the livelihoods of farmers in a case study of Bahir Dar, Ethiopia. Therefore, urban agricultural households generally have less land to cultivate because urban areas are more densely populated and have competing needs for land, leading to higher land prices and smaller available plots. Additionally, more than half of the urban (54.5%) and rural (51.7%) households' livestock which served as a means of income and nutrition diversification, and pets (such as dogs and cats) for household security and companionship.

Table 1: Socioeconomic characteristics of the study participants

Variables	Urban		Rural		Mean ($\bar{x}$)	
	Freq.	%	Freq.	%	Urban	Rural
Household size					5.6	5.8
Adults					123	121
Children					67	60
Level of Education						
No formal education	2	6.1	11	34.4		
Primary	2	6.1	6	18.8		
Secondary	13	39.4	8	25.0		
Tertiary	16	48.5	6	18.8		
Years of farming experience					13.0	19.8
Average land size					0.92	3.1
Livestock ownership						
Yes	18	54.5	15	51.7		

Field Survey, 2024

4.2 WATER FOOTPRINT ESTIMATION

4.2.1 Comparison of the total water footprint of urban and rural households

The result in Table 2 presents the water footprint results for the study district, categorized into blue, green, and gray water. Over the study period, the total water footprint of urban agricultural households was 19,516.9 m^3 per month, which is 6.6% higher than the total water footprint of rural households which is 17,088.2 m^3 per month. This implies that urban agriculture may be less water-efficient compared to rural agriculture due to factors such as higher population densities, different crop types, and less efficient water-use practices in urban agrarian settings. In this case, water-intensive agricultural products may need to be imported more frequently from rural areas with more efficient water use, into urban areas.

Urban areas have a competing need for freshwater (Huang et al., 2023), therefore water-scarce urban regions can import products that need a lot of water to produce from rural areas, a practice known as virtual water trade (Vallino, Ridolfi & Laio, 2021), which can help balance water resources more sustainably.

The breakdown of the total water footprint of urban agricultural households includes 92.1% WF_{green} (water incorporated in food), 7.7% WF_{gray} (water for daily activities like brushing teeth, showering, and washing dishes), and 0.2% WF_{blue} (water for drinking and cooking). Which is similar to the results obtained in rural agricultural households 92.3% WF_{green} , 7.5% WF_{gray} , 0.2% WF_{blue} from the study area. The similarity to the findings of Parra-Orobio et al. (2023) in Colombia and Hirpa et al. (2022) findings in Ethiopia which implies the water use patterns in Enugu possibly will be representative of broader trends in similar regions, particularly regarding the high reliance on green water for food production.

Table 2: Water footprint of the study area

Water footprint category	Urban (m^3/month)	Rural (m^3/month)
Blue Water Footprint	36.9	40.5
Green Water Footprint	17,976.1	15,764.3
Gray Water Footprint	1503.9	1283.4
Total Water Footprint	**19,516.9**	**17,088.2**

Field Survey, 2024

4.2.2 Comparison of blue water footprint of urban and rural households

Figure 8 shows the WF_{blue} distribution according to consumption patterns in rural and urban agricultural households. The WF_{blue} of rural households (40.5 m^3/month) is 4.7% greater than urban households (36.9% m^3/month) as regards water used for drinking and cooking. Generally, cooking consumes a large amount of water, contributing to more than half (56.5%) and rural and 58.8% of urban households blue water consumption in the study area. Relatively, rural households consume larger amounts of water for cooking; reflecting rural households' lifestyle and dietary habits which require higher consumption of home-cooked meals and reliance on fresh produce that requires more water for preparation (Kumbhare et al., 2023). Also, rural households may have less access to processed foods that require less water to prepare, thus relying more on cooking from scratch. The average water consumed for drinking and cooking by rural household members was 7.5Lpcd (Liters per capita per day) surpassing the values recommended by the World Health Organization (WHO) of 6.5 Lpcd to ensure drinking and food preparation as cited by Parra-Orobio et al. (2023), while the urban household meets the equivalent with a value of 6.5Lpcd for urban households.

On the other hand, direct consumption of water through drinking also takes a significant amount of house household blue water, in exemption of livestock consumption. Per capita adult daily water consumption through drinking was 3.8 litres and 3.2 litres for rural and urban adults respectively. This aligns with the World Health Organization (WHO) recommendation of a minimum of 2 litres of water per day for individuals to ensure drinking and food preparation, with a normal range between 2.5 and 3 litres (Hall and Jungner, 1993). Children consume about 50% of the amount of water consumed by adults (Parra-Orobio et al., 2023). The per capita water consumption of children per day was higher among rural households (1.8 litres) compared to urban households of approximately 1.6 litres. Both values are in the WHO recommendation that children should consume around 1.3 to 2.1 liters of water per day to maintain adequate hydration status (Suh and Kavouras, 2019). The higher drinking water consumption by rural households is related to their direct access to natural water sources (wells, rivers) which could facilitate higher water consumption. Urban households, on the other hand, are dependent on regulated and potentially more costly municipal water supplies, which could result in slightly lower consumption.

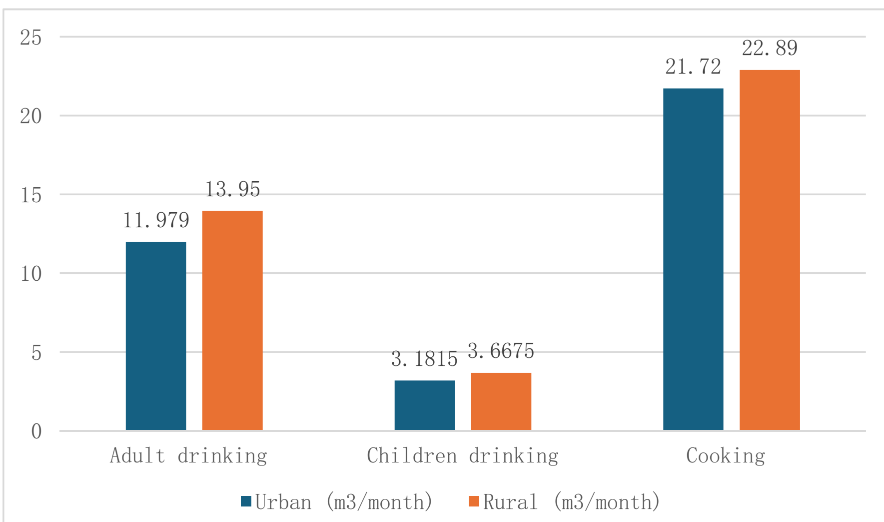

Figure 8 Blue water footprint according to the distribution in the study area

4.2.3 Comparison of green water footprint of urban and rural households

The total green water consumption of urban households of 17,976.1 m^3 per month which is statistically different (6.0% excessive) from the water green water footprint of rural agricultural households 15,764.3 m^3 per month during the period of study (Table 2). This implies that urban agrarian households have more water-intensive food preferences, while also relying on local urban agriculture and importing lesser food from rural regions.

Figure 9 shows that animal protein (beef, pork, fish, and chicken) was the type of food with a higher incidence in WFgreen in urban areas, comprising 43% compared to rural households where animal proteins make up about 37% of household nutrition (Figure 10). Urban areas probably consume more animal protein because it is more affordable due to their income level, more readily available, more convenient, and more influenced by urban culture. However, Khoiriyah et al. (2023) noted that household elasticity of demand for animal foods in urban areas can be highly price elastic. Animal protein source is associated with a severe environmental footprint from carbon and water perspectives. For example, the production of 1 kg of beef demands approximately 15,000 litters of water (Pereira et al., 2021). This implies that food consumption in urban households may have greater environmental effects, underscoring the need to encourage more environmentally friendly food choices in urban areas. Additionally, due to a greater reliance on staple crops for food, cereals (maize, wheat, rice, sorghum and millet) have a higher green water footprint (29%) in rural areas. Cereal consumption is lower (26%), and diets in urban areas are more varied. Compared to rural areas (16%), urban areas (19%) consume more fruit because it is more readily available and because they prefer varied diets (Hongrong et al., 2023).

On the other hand, tea and coffee both account for less than 1% of the total green water footprint of both rural and urban households in the study region. This negligible contribution of tea and coffee to the green water footprint in both rural and urban households implies that these beverages have minimal impact on water resources compared to other food items in the study region.

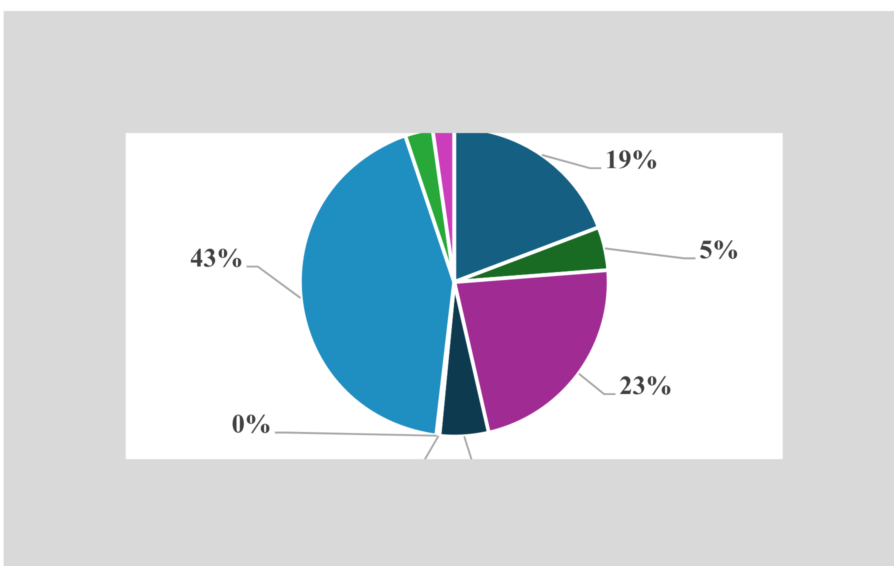

Figure 9 Distribution of green water footprint according to the type of food in urban

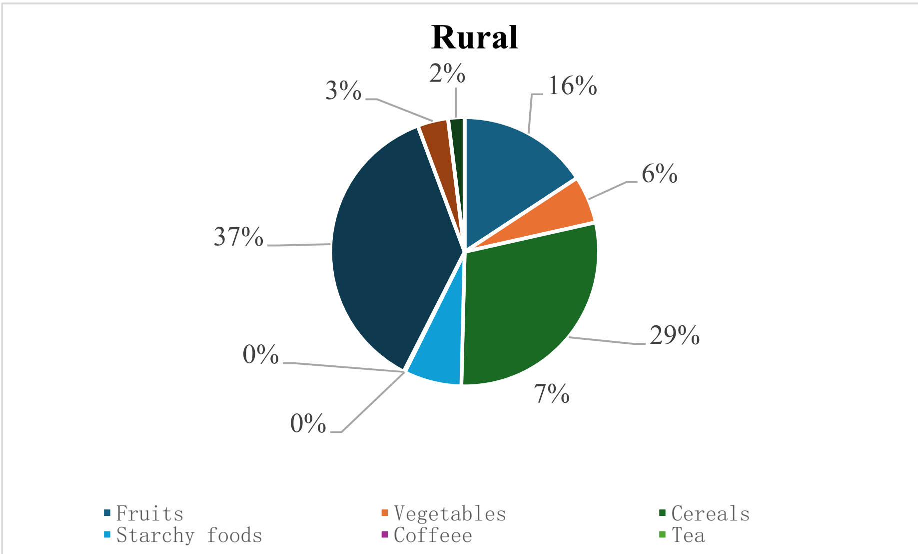

Figure 10 Distribution of green water footprint according to the type of food in rural

4.2.4 Comparison of gray water footprint of urban and rural households

The total gray water (water for daily activities like brushing teeth, showering, and washing dishes, among others) consumption of urban households of 1503.9 m^3 per month which is statistically different (7.9% excessive) from the water green water footprint of rural agricultural households 1283.4 m^3 per month during the period of study. This implies that urban areas, with higher population densities and advanced infrastructure, use more water for daily activities like showering, dishwashing, and personal hygiene.

Figure 11 showed that showering, livestock farming, dishwashing, handwashing, car washing, clothes washing and flushing of toilets contributed the most to household gray water footprint. Aside from handwashing, the contribution of these activities to household gray water are 17.8% (showering), 95.5% (livestock farming), 4.4% (dishwashing), 65.8% (car washing), 61.2% (clothes washing), 38.3% (flushing of toilet) and 10.8% (general house cleaning) higher in urban areas compared to the rural counterpart. This is linked to larger homes and better amenities in urban households also increased water consumption for maintenance and daily use compared to simpler rural living conditions (Alemken et al., 2023). Also, higher incomes and access to water-consuming appliances further contribute to greater gray water usage in urban households compared to rural counterparts. Makindara and

Birch-Thomsen (2023) noted that the transition from rural to urban areas due to population growth and housing densification impacts domestic water access, with urban centers showcasing a blend of rural and urban water service provisions. Also, livestock farming is a major contributor to gray water footprint in urban households because intensive and semi-intensive livestock farming is common in urban and periurban settings (Fan et al., 2022), compared to rural areas where livestock farming is underdeveloped and sparsely practiced. This aligns with the findings of Grison et al. (2022) who found that the relationship between livestock farming, and urban areas has evolved over time, with peri-urban farmers adapting their production models to meet urban demands, leading to increased water usage and pollution. Fan et al. (2022) further argued that animal husbandry is a major contributor to the gray water footprint in Southeast China. Other household activities like shaving and tooth brushing generally contribute less to the gray water footprint in both rural and urban homes.

On the other hand, results showed that crop farming contributed approximately 93% more to household gray water footprint in rural areas than in urban areas with only 7%. This glaring contrast suggests that rural households are more dependent on farming for their livelihoods, which involves considerable water usage. Rural households in the study region primarily engage in crop farming, resulting in higher water usage for irrigation and farming activities contributing to the gray water footprint. In contrast, urban households have constrained space and rely less on farming, often using more water-efficient technologies. Rural homes have greater access to land and water for agriculture, while urban homes prioritize water use for domestic purposes. Additionally, urban household economies are diversified with less emphasis on farming, hence lower water usage for agricultural purposes unlike rural household economies which are more dependent on agriculture, imposing higher water use for crop farming.

Also, collected data showed that majority of the rural farming households rely on the mixture of rain and artificial as a source of water for farming, unlike the urban farming households that depend more on rain. This implies that rural households might be more proactive in ensuring water security for farming by using irrigation, potentially leading to more stable crop production compared to urban households. On the other hand, the greater dependence on rain in urban farming implies limited investment in irrigation infrastructure, which could be due to space constraints, economic factors, and prioritization of water for other uses. Therefore, rural areas could have better adaptation strategies for farming, combining natural and artificial water sources to buffer against the unpredictability of rainfall, while urban farming might need to enhance its resilience through improved water management practices.

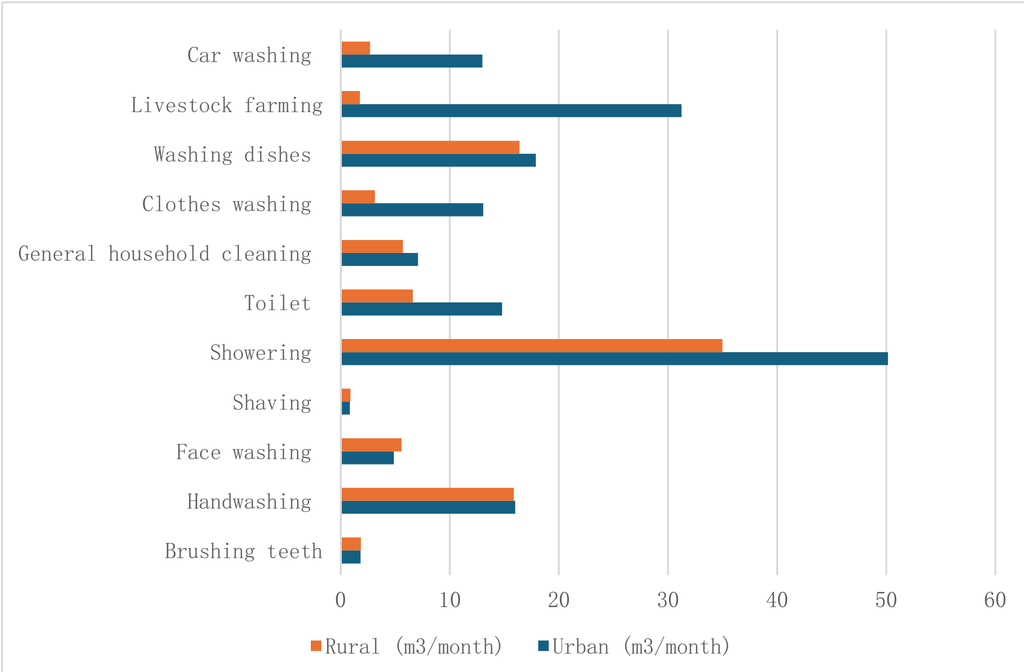

Figure 11 Distribution of gray water footprint according to the type of food in rural households

4.3 IDENTIFICATION OF ACTIVITIES ASSOCIATED WITH HIGH INTRA-HOUSEHOLD WATER CONSUMPTION

Vester matrix was utilized to systematically pinpoint the key issues contributing to high water consumption in urban and rural households of the study region, which had not been previously identified by relevant stakeholders in the study region.

Table 3 provides an evaluation of each problem in urban households, and Figure 12 depicts their relationships on a Cartesian plane in urban households. The analysis exposed the degree of impact of each factor. The *most critical issue* identified was P6 (irrational water use). Water wastage was the most prominent issue in the study area. These findings align with the findings of Parra-Orobio et al. (2023) in a low-income urban neighborhood (Fatima, Colombia) who found that irrational use of water resources was the most notorious issue in their study area. Results show that *the most active problem* was P11 (lack of water-saving devices). The *passive problem* identified was P9 (lack of water saving irrigation system). The *indifferent problems* included: P1 (receiving lesser amount of rainfall than usual), P2 (lack of knowledge on how to reuse wastewater), P3 (lack of inspection and maintenance of household pipes), P4 (lack of re-use water), P5 (lack of household water metering), P7 (washing clothes excessively), P10 (cultivating large farmland), P12 (large household size), and P13 (planting high-water demand crops).

Table 3: Vester matrix for the high-water consumption activity in urban agricultural households

Code	**Variables**	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**	**P12**	**P13**	**Total Active**
P1	Receiving lesser amount of rainfall than usual	0	0	0	0	0	1	1	1	0	1	0	1	1	**6**
P2	Lack of knowledge on how to reuse wastewater	0	0	0	3	0	3	2	0	3	0	1	0	0	**12**
P3	Lack of inspection and maintenance of household pipes	0	0	0	0	1	0	0	0	0	0	0	0	0	**1**
P4	I do not re-use water	0	3	0	0	0	3	2	0	0	0	0	0	0	**8**
P5	Lack of household water metering	0	0	2	0	0	2	0	0	0	0	1	0	0	**5**
P6	I use water irrationally	0	3	2	3	2	0	3	0	3	0	3	1	1	**21**
P7	I wash clothes excessively	0	0	0	0	0	3	0	0	0	0	0	3	0	**6**
P8	Lack of rainwater harvesting	0	1	0	0	0	0	0	0	3	0	2	0	0	**6**
P9	Lack of water saving irrigation system	0	0	3	1	1	1	0	1	0	0	3	0	0	**10**
P10	I cultivate large farmland	0	0	0	0	0	1	0	0	1	0	1	3	1	**7**
P11	I do not have water-saving devices	0	1	2	1	1	3	0	3	3	0	0	0	0	**14**
P12	I have large household size	0	0	0	0	0	1	0	3	1	3	0	0	1	**9**
P13	Planting high-water demand crops	1	0	0	0	0	0	0	0	0	1	0	2	0	**4**
Total Passive		**1**	**8**	**9**	**8**	**5**	**18**	**8**	**8**	**14**	**5**	**11**	**10**	**4**	**109**

Note: P means problem
Source: Author

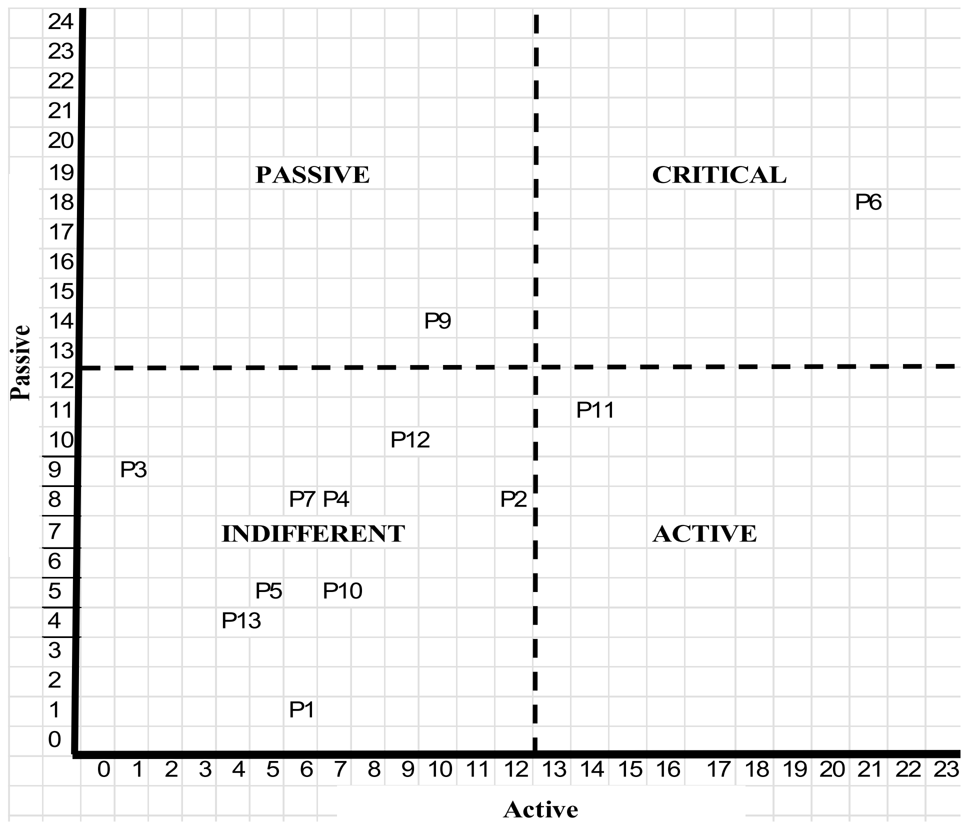

Figure 12 Cartesian plane of high-water consumption in urban agricultural households

Note: P stands for problem

Table 4 provides an evaluation of each problem in rural households, and Figure 13 depicts their relationships on a Cartesian plane in urban households.

The *most critical issue* identified was P11 (lack of water-saving devices). This is in tandem with the findings of Murwirapachena (2021) who recommend that adopting sustainable water use techniques and implementing water-saving strategies can significantly reduce domestic water demand. Results show that P8 (poor storage of water in open tanks) and P9 (lack of water saving irrigation system) were *the active problem*s associated with high intra-household water consumption. This means that strategic water infrastructure projects need to be implemented to reduce water losses due to poor water storage and water-saving devices. Other problems including P1 (lack of knowledge on how to reuse wastewater), P2 (planting high-water demand crops), P3 (lack of household water metering), P4 (lack re-use water), P5 (lack of inspection and maintenance of household pipes), P6 (receiving lesser amount of rainfall than usual), P7 (cultivating large farmland), P10 (large household size) and P12 (wash clothes excessively) were identified as *indifferent issues*.

Table 4: Vester matrix for the high-water consumption in rural agricultural households

Code	Variables	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	Total Active
P1	Lack of knowledge on how to reuse wastewater	0	0	0	3	0	0	0	0	1	0	1	2	**7**
P2	Planting high-water demand crops	0	0	0	0	0	3	1	2	1	0	1	0	**8**
P3	Lack of household water metering	0	0	0	0	3	0	0	1	2	0	2	0	**8**
P4	I do not re-use water	3	0	0	0	0	0	0	0	0	0	0	1	**4**
P5	Lack of inspection and maintenance of household pipes	0	0	1	0	0	0	0	0	0	0	1	0	**2**
P6	Receiving lesser amount of rainfall than usual	0	1	0	0	0	0	1	1	0	0	0	0	**3**
P7	I cultivate large farmland	0	1	0	0	0	0	0	1	0	3	0	1	**6**
P8	Poor storage of water in open tanks	2	0	0	1	1	1	1	0	3	1	3	0	**13**
P9	Lack of water saving irrigation system	1	0	0	2	1	2	0	3	0	1	3	0	**13**
P10	I have large household size	0	2	0	0	0	0	3	1	1	0	1	3	**11**
P11	I do not have water-saving devices	1	0	1	3	1	1	0	3	3	1	0	0	**14**
P12	I wash clothes excessively	2	0	0	3	0	0	0	0	0	3	3	0	**11**
Total Passive		**9**	**4**	**2**	**12**	**6**	**7**	**6**	**12**	**11**	**9**	**15**	**7**	**100**

Note: P means problem
Source: Author

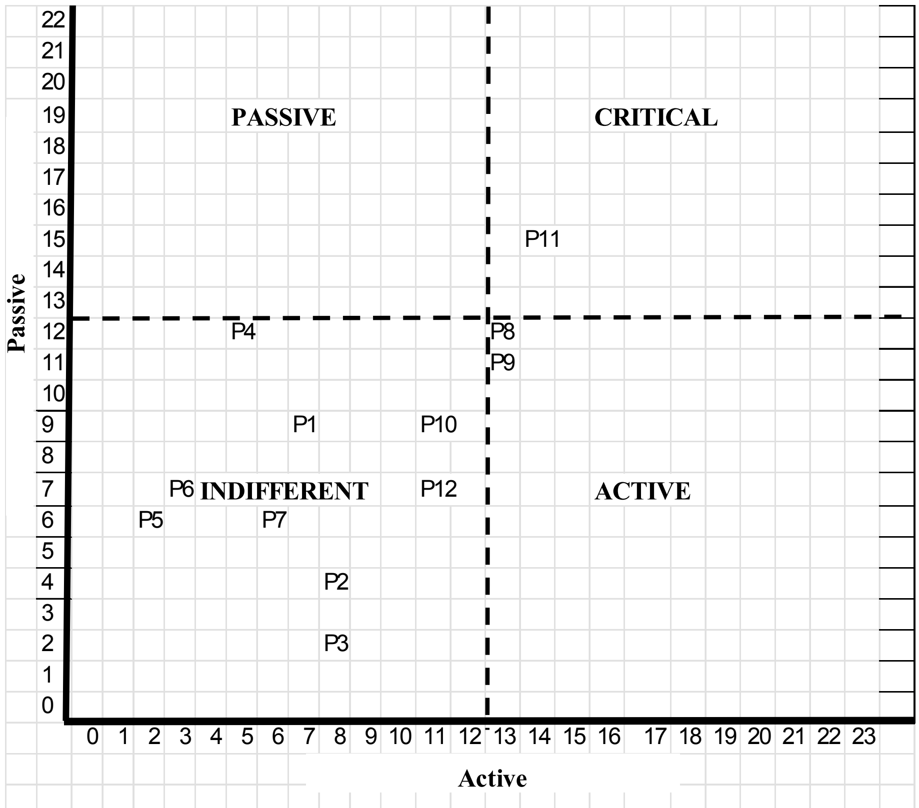

Figure 13 Cartesian plane of high-water consumption in rural agricultural households

Note: P stands for problem

4.4 SOCIO-ECONOMIC CHARACTERISTICS INFLUENCING TOTAL WATER FOOTPRINT OF AGRICULTURAL HOUSEHOLDS

Table 5 shows the influence of socio-economic characteristics of respondents on their total water footprint in urban households. The regression results indicate that among the factors studied, land size ($t = 4.783$; $p \leq 0.001$) significantly influences the total water footprint of urban agricultural households. This means that as land size increases, the total water footprint of urban households also increases. Urban agricultural households with larger land sizes probably produce more crops, engage in a wider range of agricultural activities, and require more extensive irrigation systems, all of which raise water consumption (Karo et al., 2023). Jegnie et al. (2023) noted that larger operations might not always attain economies of scale in water use, particularly if irrigation techniques are ineffective.

On the other hand, there was no significant relationship between the total water footprint of urban households and other socio-economic characteristics such as household size ($t = 1.268$; $p = 0.217$), number of adults ($t = -0.915$; $p = 0.369$), number of children ($t = 0.002$; $p = 0.998$), level of education (t= -0.740; p = 0.466), years of farming experience (t= 0.476; p= 0.639), and livestock ownership (t= 1.042; p= 0.307). Therefore, the null hypothesis is accepted for these factors.

The R square value represents the proportion of variability in the dependent variable (total water footprint) explained by changes in the independent variables (socio-economic factors) as expressed by the regression model. The adjusted R square (0.496) was the estimated r^2 (coefficient of determination) for the population. Therefore, land size was able to explain approximately 49.6% of the variance in the total water footprint of urban households.

Table 5: Effect of socio-economic characteristics on total water footprint of urban agricultural households

	Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig
		B	Std. Error	Beta		
1	(Constant)	176797.944	286100.728		.618	0.542
	Household size	107721.895	84986.196	.583	1.268	.217
	Number of adults	-86154.409	94134.806	-.364	-.915	.369
	Number of children	192.556	82533.482	.001	.002	.998
	Level of education	-177523.049	239838.818	-.099	-.740	.466
	Years of farming experience	3676.544	7731.901	.073	.476	.639
	Land size	185473.091	38780.622	.648	4.783	**<.001**
	Livestock ownership	141430.809	135747.516	.164	1.042	.307

Dependent Variable: Total Water Footprint, R Squared = 0.606, Adjusted R squared = 0.496, Sig. <.001

Table 6 shows the influence of socio-economic characteristics of respondents on their total water footprint in rural households. The regression results indicate that among the factors studied, land size ($t= 2.114$; $p \leq 0.047$) significantly influences the total water footprint of rural agricultural households. This means that as land size increases, the total water footprint of rural households also increases, which is similar to the results from the urban counterpart.

On the other hand, there was no significant relationship between the total water footprint of urban households and other socio-economic characteristics such as household size ($t= -0.381$; $p= 0.707$), number of adults ($t= -0.009$; $p= 0.993$), number of children ($t= -0.185$; $p= 0.855$), level of education ($t= 0.582$; $p = 0.567$), years of farming experience ($t= -0.792$; $p= 0.438$), and livestock ownership ($t= 0.973$; $p= 0.342$). Therefore, the null hypothesis is accepted for these factors.

The R square value represents the proportion of variability in the dependent variable (total water footprint) explained by changes in the independent variables (socio-economic factors) as expressed by the regression model. The adjusted R square (0.572) was the estimated r^2 (coefficient of determination) for the population. Therefore, land size was able to explain approximately 57.2% of the variance in the total water footprint of urban households.

Table 6: Effect of socio-economic characteristics on total water footprint of rural agricultural households

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig
		B	Std. Error	Beta		
1	(Constant)	-28137.985	193461.714		-.145	.886
	Household size	102644.585	269546.799	.932	.381	.707
	Number of adults	-2457.786	275160.986	-.013	-.009	.993
	Number of children	-50805.085	274687.725	-.272	-.185	.855
	Level of education	76739.143	131793.151	.106	.582	.567
	Years of farming experience	-4562.576	5763.536	-.129	-.792	.438
	Livestock ownership	107302.737	110233.136	.154	.973	.342
	Land size	24968.621	11810.685	.298	2.114	**.047**

Dependent Variable: Total Water Footprint, R Squared = 0.683, Adjusted R squared = 0.572, Sig. < .05

5. CONCLUSION

During the preparation of this master's thesis, attention was focused on comparing the total water footprint of urban and rural agricultural households and systematically pinpointing activities associated with high intra-household water consumption. Additionally, the socioeconomic characteristics that influence the total water footprint of both rural and urban households were also determined.

The research includes an analysis of the socioeconomic features of the respondents, which showed that both rural and urban rely on artificial or managed water sources such as boreholes and water tankers as major water sources for their household activities. The analysis also showed that the mean household size in both rural and urban areas is 6 persons which contributes to a valuable pool of labour for agricultural activities, while also contributing to household water consumption.

According to findings from the study, rural households' monthly water footprint (17,088.2 m^3) is 6.6% lower than that of urban agricultural households (19,516.9 m^3). This shows that a variety of factors, including different crop types, higher population densities, and less effective water use practices, may contribute to urban agriculture's lower water efficiency. As a solution, it is recommended that water-intensive agricultural products may need to be imported into urban areas from more water-efficient rural areas to aid in the more sustainable balancing of water resources. Urban households' overall water footprint is composed of 92.1% green water, which is water used in food, 7.7% gray water, which is water used for daily tasks, and 0.2% blue water, which is water used for drinking and cooking. This distribution—92.3% green water, 7.5% gray water, and 0.2% blue water—is comparable to that found in rural homes. These results are consistent with similar research conducted in Ethiopia and Colombia, suggesting that the patterns of water use in Enugu might be indicative of more general trends in comparable areas, especially given the region's heavy reliance on green water for food production.

Animal protein (beef, pork, fish, and chicken) was the type of food with a higher incidence of green water footprint in urban areas compared to rural households. This is related to the relatively higher purchasing power of urban households since animal protein sources is expensive. However, animal protein sources contribute to the green water footprint significantly. It is therefore recommended that households should adopt water-conscious food and dietary choices to take action.

As regards the blue water footprint, findings showed that rural households consume larger amounts of water for cooking and drinking which is a reflection of rural households' lifestyle and dietary habits which require higher consumption of home-cooked meals and reliance on fresh produce that require more water for preparation. It is therefore recommended that strategic water-saving technologies and innovations need to be disseminated to rural households in the region to help in better management of freshwater resources for cooking while also encouraging the reuse of wastewater. The analysis of the gray water footprint revealed that showering, livestock farming, dishwashing, handwashing, car washing, clothes washing, and toilet flushing significantly contributed to the gray water footprint in urban households compared to rural ones. Notably, water used for animal drinking and cleaning livestock equipment ranked the highest. Therefore, a data-driven policy is needed to promote sustainable water use in urban livestock farming.

The Vester matrix was used to systematically identify key issues contributing to high water consumption in urban and rural households, previously overlooked by stakeholders. Water wastage emerged as the most prominent issue. The critical issues identified were irrational water use in urban households and the lack of water-saving devices in rural households. Adopting sustainable water use techniques and implementing water-saving strategies can significantly reduce domestic water demand. Regression analysis indicated that farmland size positively influences the total water footprint of both urban and rural agricultural households, meaning that as land size increases, so does water consumption. Consequently, regulating water use patterns for farmers with larger agricultural operations is necessary.

6. LITERATURE

1. Abu-Bakar, H., Williams, L. D., & Hallett, S. H. (2023). Contextualising household water consumption patterns in England: A socio-economic and socio-demographic narrative. Cleaner and Responsible Consumption. https://doi.org/10.1016/j.clrc.2023.100104
2. Adeoti, O. S., Kandasamy, J., & Vigneswaran, S. (2023). Water infrastructure sustainability in Nigeria: A systematic review of challenges and sustainable solutions. *Water Policy, 25*(11), 1094. doi: 10.2166/wp.2023.173.
3. Adewole, W.A., Ayoade, A.R., & Oladapo, E.O. (2021). Attitude of rural households of southwestern Nigeria towards utilization of water sanitation facilities. International Journal of Research. https://doi.org/10.29121/GRANTHAALAYAH.V9.I3.2021.3566

4. Agwu, J., and Okhimamhe, A. (2009). Gender and Climate Change in Nigeria: A Study of Four Communities in North-Central and South-eastern Nigeria. Heinrich Böll Stiftung (HBS), 70.
5. Alemken, J., Fogarty, J., & Iftekhar, S. (2023). Urban Residential Water Demand and Household Size: A Robust Meta□Regression Analysis. Economic Record. Advance online publication. https://doi.org/10.1111/1475-4932.12751
6. Alexoaei, A.P., Cojanu, V., & Coman, C.-I. (2021). On Sustainable Consumption: The Implications of Trade in Virtual Water for the EU's Food Security. Sustainability, 13, 11952. https://doi.org/10.3390/su132111952
7. Ali, M., & Terfa, A. B. (2012). State of water supply and consumption in urban areas at household level: A case study of East Wollega Zone, Ethiopia.
8. Aubry, C., & Kebir, L. (2013). Shortening food supply chains: A means for maintaining agriculture close to urban areas? The case of the French metropolitan area of Paris. Food Policy, 41, 85–93.
9. Avazdahandeh, S., & Khalilian, S. (2021). The effect of urbanization on agricultural water consumption and production: The extended positive mathematical programming approach. Environmental Geochemistry and Health. https://doi.org/10.1007/s10653-020-00668-2
10. Barthel, S., & Isendahl, C. (2013). Urban gardens, agriculture, and water management: Sources of resilience for long-term food security in cities. Ecological Economics, 86, 224–234.
11. Birhanu, G.A. (2023). The practice of peri-urban land acquisition by expropriation for housing purposes and the implications: The case of Bahir Dar, Ethiopia. Urban Science. doi: 10.3390/urbansci7020041
12. Consultative Group for International Agricultural Research (CGIAR). (n.d.). Shining the spotlight on urban farming. Retrieved from https://www.iwmi.cgiar.org/archive/wle/news/shining-spotlight-urban-farming/index.html (Assessed: 20 May, 2024)
13. Costello, C., Oveysi, Z., Dundar, B., & McGarvey, R. (2021). Assessment of the effect of urban agriculture on achieving a localized food system centered on Chicago, IL using robust optimization. Environmental Science & Technology, 55, 2684–2694.
14. Daigger, G. T., Newell, J. P., Love, N. G., McClintock, N., Gardiner, M., Mohareb, E., Horst, M., Blesh, J., & Ramaswami, A. (2015). Scaling up agriculture in city-regions to mitigate FEW system impacts (Publication No. CSS15-47). Ann Arbor, MI: School of Natural Resources and Environment, Department of Civil and Environmental Engineering, University of Michigan.
15. Deelstra, T., & Girardet, H. (2000). Urban agriculture and sustainable cities. In N. Bakker, M. Dubbeling, S. Gündel, U. Sabel-Koshella, & H. de Zeeuw (Eds.), Growing cities, growing food: Urban agriculture on the policy agenda (pp. 43–66). Feldafing, Germany: Zentralstelle für Ernährung und Landwirtschaft (ZEL).
16. Deng, Xiao-ju. (2014). Comparative analysis of urban water footprint: A case study of Shanghai and Chongqing. Resources and Environment in the Yangtze Basin.
17. Dobrescu, I., Ercin, E., te Winkel, T., & Holmatov, B. (2020). Water Footprint Analysis of Central Asia (Full technical report vs 1). Revised & abbreviated version — 2022 by Libert, B. & Dobrescu, I. Retrieved from https://bluepeace-centralasia.ch/knowledge/publications/BluePeace-Water_Footprint_Analysis_en.pdf (Assessed: 20 May, 2024)

18. Enel Group (2022). The water footprint: how to safeguard the most precious resource. Retrieved from https://www.enel.com/company/stories/articles/2022/10/water-footprint (Assessed: 15 May, 2024)

19. Fan, Y., Zhang, C., Wang, Y. C., Zhu, L., Jin, J., Deng, H., Ling, H., Shi, R., He, Y., Yu, J., & Jiang, P. (2022). Analysis of gray water footprint changes and driving forces caused by sectoral trade in Southeast China. Frontiers in Environmental Science. https://doi.org/10.3389/fenvs.2022.864346
20. García SIN, Toro MJ. (2013). Evaluation of the Water Footprint Generated by the Commercial and Residential Sectors of the La Florida Neighborhood (Bogotá D.C.). Environmental Engineering. Bogotá D.C.: Universidad de Libre 2013.
21. Gondhalekar, D., & Ramsauer, T. (2016). Nexus City: Operationalizing the urban water-energy-food nexus for climate change adaptation in Munich, Germany. Urban Climate, 19, 28–40. https://doi.org/10.1016/j.uclim.2016.11.004
22. Grid 3 (2024). ESRI Imagery. GRID3 Nigeria, Openstreet map. Retrieved from https://grid3.org/geospatial-data-nigeria
23. Grison, J., Pecqueur, B., Delfosse, C., & Le Gall, P. (2022). Livestock farming in relations between urban districts and the mountains – The case of Grenoble. Journal of Alpine Research | Revue de Géographie Alpine. Advance online publication. https://doi.org/10.4000/rga.10952
24. Hall, P., & Jungner, I. (1993). Hard drinking water and ischemic heart disease: calcium, blood lipids, and acute myocardial infarcts. Journal of Medical Systems. doi: 10.1007/BF00996958
25. Hirpa, B. A., Adane, G. B., Asrat, A., & Nedaw, D. (2022). Spatio-temporal variability and trend of water footprints in the upper Awash basin, central Ethiopia. Journal of Hydrology, 608, 127686.
26. Hoekstra A.Y. (Ed.) (2003). Virtual Water Trade: Proceedings of the International Expert Meeting on Virtual Water Trade, Delft, The Netherlands, 12–13 December 2002, Value of Water Research Report Series No. 12. IHE, Delft, the Netherlands (2003).
27. Hoekstra, A. Y. (2016). A critique on the water-scarcity weighted water footprint in LCA. Ecological Indicators, 66, 564-573. https://doi.org/10.1016/j.ecolind.2016.02.026.
28. Hoekstra, A. Y., Chapagain, A. K., Aldaya, M. M., & Mekonnen, M. M. (2011). The Water Footprint Assessment Manual: Setting the Global Standard. Retrieved from https://www.fao.org/sustainable-food-value-chains/library/details/en/c/266049/ (Assessed: 20 June, 2024)
29. Hoekstra, A. Y., Chapagain, A. K., Aldaya, M. M., & Mekonnen, M. M. (2009). Water footprint manual: State of the art 2009. Water footprint network, enschede, the Netherlands, 255.
30. Hoekstra, A.Y., Chapagain, A.K., Aldaya, M.M. and Mekonnen, M.M. (2011). The Water Footprint Assessment Manual. Retrieved from https://waterfootprint.org/resources/TheWaterFootprintAssessmentManual_English.pdf (Assessed: 12 June, 2024)
31. Hongrong, H., La, Z., Zhibin, L., Xiangxiang, J., & Pute, W. (2023). Effects of multidimensional urbanisation on water footprint self-sufficiency of staple crops in China. Journal of Hydrology. https://doi.org/10.1016/j.jhydrol.2023.129275

32. Huang, H., Zhuo, L., Li, Z., Ji, X., & Wu, P. (2023). Effects of multidimensional urbanisation on water footprint self-sufficiency of staple crops in China. Journal of Hydrology. https://doi.org/10.1016/j.jhydrol.2023.129275
33. Hubert de Bon, Laurent Parrot, Paule Moustier. Sustainable urban agriculture in developing countries. A review. Agronomy for Sustainable Development, 2010, 30 (1), ff10.1051/agro:2008062ff. ffhal00886446
34. Ibeje, A. O. (2021). Regionalization of the meteorological features of southeast region of Nigeria. Nigerian Journal of Engineering Science and Technology Research Vol, 7(1), 160-170.
35. Igbokwe, J. I., Akinyede, J. O., Dang, B., Alaga, T., Ono, M. N., Nnodu, V. C., et al. (2008). Mapping and monitoring of the impact of gully erosion in Southeastern Nigeria with satellite remote sensing and Geographic Information System. Int. Arch. Photogram. Remote Sens. Spatial Inform. Sci. 37(part B8), 865–872.
36. International Atomic Energy Agency (IAEA) (2023). Agricultural water management. Retrieved from https://www.iaea.org/topics/agricultural-water-management
37. International Institute for Sustainable Development (2018). FAO Report Presents Global Baseline Data for Monitoring Water-use Efficiency Retrieved from https://sdg.iisd.org/news/fao-report-presents-global-baseline-data-for-monitoring-water-use-efficiency/
38. Istifanus, V. (2017). Determinants of domestic water use in Bauchi Metropolis: A model perspective. Journal of Environment and Earth Science.
39. Jegnie, A., Fogarty, J., & Iftekhar, S. (2023). Urban residential water demand and household size: A robust meta□regression analysis. Economic Record. https://doi.org/10.1111/1475-4932.12751
40. Jhilam Sinha et al (2023). Hydrological sustainability of international virtual water trade. Environ. Res. Lett. 18 124037. DOI: 10.1088/1748-9326/ad0861
41. Karo, R., Sitepu, K., & Sebayang, V. B. (2023). Keputusan rumah tangga dalam menerapkan pertanian perkotaan (Household decisions in implementing urban farming). Jurnal Agribisnis dan Komunikasi Pertanian. https://doi.org/10.35941/jakp.6.1.2023.9113.1-13
42. Khoiriyah, N., Apriliawan, H., & Forgenie, D. (2023). Analyzing household demand for animal food as a source of protein: The case of rural Gorontalo Province, Indonesia. Agricultural Socio-Economics Journal. doi: 10.21776/ub.agrise.2023.023.2.13
43. Kumbhare, N. V., Sangeetha, V., & Padaria, R. N. (2023). Food and nutrition consumption of rural households in northern India. Indian Journal of Extension Education. doi: 10.48165/ijee.2023.59111
44. Langemeyer, J., Madrid-Lopez, C., Beltran, A. M., & Mendez, G. V. (2021). Urban agriculture? A necessary pathway towards urban resilience and global sustainability? Landscape and Urban Planning, 210, 104055.
45. Leiva, K.Y., & Álvarez, J.R. (2021). Analysis and proposal for improvement in the logistics system of a water treatment equipment trading company. In Proceedings of the LACCEI International Multi-Conference for Engineering, Education and Technology, Bogota, Colombia, 19–23 July 2021.
46. Li, H., Wei, L., Chen, C., & Wang, Z. (2022). The impact of consumption patterns and urbanization on the cross-regional water footprint in China: A decomposition analysis. Frontiers in Environmental Science. https://doi.org/10.3389/fenvs.2021.792423

47. Lovell, S. T., & Taylor, J. R. (2013). Supplying urban ecosystem services through multifunctional green infrastructure in the United States. Landscape Ecology, 28(8), 1447–1463. https://doi.org/10.1007/s10980-013-9912-y
48. Makindara, J., & Birch-Thomsen, T. (2023). Domestic practices for accessing water and rural-urban transformations: Example of emerging urban centres in Tanzania. International Journal of Water Resources Development. Advance online publication. https://doi.org/10.1080/07900627.2023.2207684
49. Mark, S., Johnson, M. J., Lathuillière, T., Tooke, R., & Coops, N. C. (2015). Attenuation of urban agricultural production potential and crop water footprint due to shading from buildings and trees. Environmental Research Letters, 10(6), 064007. https://doi.org/10.1088/1748-9326/10/6/064007
50. Mehla, M. (2022). Regional water footprint assessment for a semi-arid basin in India. PeerJ, 10, e14207. https://doi.org/10.7717/peerj.14207
51. Mehla, M., Kothari, P., Singh, S. R., Bhakar, S., & Yadav, K. K. (2023). Water footprint assessment and its importance in Indian context: A meta-review. Water Supply. https://doi.org/10.2166/ws.2023.174
52. Mekonnen, M.M., & Hoekstra, A.Y. (2013). Water footprint benchmarks for crop production. Value of Water Research Report Series No. 64, UNESCO-IHE, Delft, the Netherlands.
53. Mohammed, N. C., & Charles, P. (2016). Political economy analysis of small-scale farmers and food security in Nigeria. European Journal of Business and Social Science, 5(4), 35-49.
54. Murwirapachena, G. (2021). Understanding household water-use behaviour in the city of Johannesburg, South Africa. Water Policy, 23(6), 1266–1283.
55. Narmilan, A., Puvanitha, N., Niroash, G., Vassanthini, R., & Sugirtharan, M. (2021). Domestic water consumption pattern and awareness of urban households. International Journal of Human Capital in Urban Management. https://doi.org/10.22034/IJHCUM.2021.03.02
56. National Population Commission (NPC) (2006). The 2006 Nigeria Demographic and Health Survey: Findings and Implications for Action, South East Zone. Abuja: Government Printer, pp. 87-90.
57. Nydrioti, I., Moutsaki, M.-M., Leounakis, N., & Grigoropoulou, H. (2023). Implementation of the Water Footprint as a water performance indicator in industrial manufacturing units located in Greece: Challenges & Prospects. National Technical University of Athens. https://doi.org/10.21203/rs.3.rs-2568685/v
58. Okenmuo, F. C., Ibeh, K. G., & Obalum, S. E. (2023). The menace of widespread gully erosion in southeastern Nigeria: Litho-anthropogenic history and management and policy issues. In E. C. Igwe, I. Uko, & A. O. Onunwa (Eds.), Valedictorian Festschrift in Honour of Professor Peter Chinedum Nnabude (pp. 61-79). Cadventures Press, Umunya, Anambra State, Nigeria.
59. Okorafor, O. O., Akinbile, C. O., & Adeyemo, A. J. (2017). Soil erosion in South Eastern Nigeria: A review. Scientific Research Journal (SCIRJ), Volume V(Issue IX), 30. ISSN 2201-2796. Pp 30 -37.
60. Okorafor, Okay, O., Oluwakunmi, C., & Jonathan, A. (2017). Soil Erosion in South Eastern Nigeria: A Review. Retrieved from https://www.semanticscholar.org/paper/Soil-Erosion-in-South-Eastern-Nigeria:-A-Review-Okorafor-Okay/00bd4fdf7e6d911261c538418cb98d8aa5924d6f (Assessed: 17 June, 2024)

61. Okoronkwo DJ, Ozioko RI, Ugwoke RU, Nwagbo UV, Nwobodo C, Ugwu CH, Okoro GG and Mbah EC (2024) Climate smart agriculture? Adaptation strategies of traditional agriculture to climate change in sub-Saharan Africa. Front. Clim. 6:1272320. doi: 10.3389/fclim.2024.1272320
62. Olawuyi, S.O., & Mushunje, A.A. (2019). Determinants of adoption and use-intensity of soil and water conservation practices among smallholder farmers in Nigeria. African Journal of Food, Agriculture, Nutrition and Development. https://doi.org/10.4314/ajfand.v19i3.17745
63. Opitz, I., Berges, R., Piorr, A., & Krikser, T. (2016). Contributing to food security in urban areas: Differences between urban agriculture and peri-urban agriculture in the Global North. Agriculture and Human Values, 33, 341–358.
64. Orsini, F., Kahane, R., Nono-Womdim, R., & Gianquinto, G. (2013). Urban agriculture in the developing world: A review. Agronomy for Sustainable Development, 33(4), 695-720. https://doi.org/10.1007/s13593-013-0143-z.
65. Parra-Orobio, B.A., Soto-Paz, J., Ramos-Santos, A., Sanjuan-Quintero, K.F., Saldaña-Escorcia, R., Dominguez-Rivera, I.C., & Sánchez, A. (2023). Assessment of the water footprint in low-income urban neighborhoods from developing countries: Case study Fátima (Gamarra, Colombia). Sustainability, 15(7115). https://doi.org/10.3390/su15097115
66. Pereira, G.M., Egito, A.A., Gomes, R.C., Ribas, M.N., Junior, R.T., Junior, J.F., & Menezes, G. (2021). Water requirements of beef production can be reduced by genetic selection. Animal, 15, 100142.
67. Qiu, J., Zhao, H., Bravo, L., & Ryals, J. M. (2023). Urban agriculture and its sustainability implications on the food-water-energy nexus. EDIS. https://doi.org/10.32473/edis-fr463-2023
68. Rahayu, P., & Fitria, E. R. (2019). Towards sustainable communities: Socioeconomic determinants of domestic water consumption in Surakarta City, Indonesia. MATEC Web of Conferences, 280, 05016. https://doi.org/10.1051/matecconf/201928005016
69. Rathore, L. S., Kumar, M., Hanasaki, N., Mekonnen, M. M., & Raghav, P. (2023). Transition from Rain-fed to Irrigation-fed Agriculture in Rural Areas to Exacerbate Urban Water Scarcity. doi: 10.22541/essoar.168056796.60935249/v1
70. Ray, C., McInnes, D. and Sanderson, M. (2018) Virtual water: its implications on agriculture and trade, Water International, 43:6, 717-730, DOI: 10.1080/02508060.2018.1515564
71. Singh, V. K., Rajanna, G. A., Paramesha, V., & Upadhyay, P. K. (2022). Agricultural water footprint and precision management. In P. Kumar, A. K. Pandey, S. K. Singh, S. S. Singh, & V. K. Singh (Eds.), Agricultural water management: Challenges and solutions (pp. 11). https://doi.org/10.1002/9781119808565.ch11
72. Specht, K., Siebert, R., Hartmann, I., Freisinger, U. B., Sawicka, M., Werner, A., Thomaier, S., Henckel, D., Walk, H., & Dierich, A. (2014). Urban agriculture of the future: An overview of sustainability aspects of food production in and on buildings. Agriculture and Human Values, 31, 33–51.
73. Stack, Whitney K., & Whitney, Kristoffer. (2018). John Anthony Allan's 'Virtual Water': Natural Resources Management in the Wake of Neoliberalism. Environment & Society Portal, Arcadia, (11). doi:10.5282/rcc/8316.

74. Suh, H., & Kavouras, S. A. (2019). Water intake and hydration state in children. European Journal of Nutrition. doi: 10.1007/S00394-018-1869-9
75. United Nations. (2014). World urbanization prospects ST/ESA/SER.A/366. In Department of Economic and Social Affairs. New York: United Nations.
76. United States Agency for International Development (USAID) (2021). Nigeria Water Resources Profile Overview. Retrieved from https://winrock.org/wp-content/uploads/2021/08/Nigeria_Country_Profile_Final.pdf (Assessed: 2 July 2024)
77. Vallino, E., Ridolfi, L. & Laio, F. (2021). Trade of economically and physically scarce virtual water in the global food network. Sci Rep 11, 22806. https://doi.org/10.1038/s41598-021-01514-w
78. Vanguard (2021). South-East residents lament absence of safe drinking water. Retrieved from https://www.vanguardngr.com/2021/05/south-east-residents-lament-absence-of-safe-drinking-water/ (Assessed: 3 June, 2024)
79. WFP (World Food Program). (2016). Nigeria situation report no. 01, 13 September 2016. Retrieved from https://www.reliefweb.int/report/nigeria/wfp-nigeria-situation-report-01-13-september-2016 (Assessed: 20 June, 2024)
80. Yu, Zhang., Qing, Tian., Huan, Hu., & Miao, Yu. (2019). Water Footprint of Food Consumption by Chinese Residents. International Journal of Environmental Research and Public Health. https://doi.org/10.3390/IJERPH16203979
81. Zhang, P., Zou, Z., Liu, G., Feng, C., Liang, S., & Xu, M. (2020). Socioeconomic drivers of water use in China during 2002–2017. Resources, Conservation and Recycling, 154, 104636. https://doi.org/10.1016/j.resconrec.2019.104636

APPENDIX

Anex A: Tables of average water footprint of food items in Nigeria and household parameters

Anex A1: Average Water Footprint of Food Items in Nigeria

Food Item	Quantity	Total volume of water (m^3 per year)	Total volume of water (litres per year)	Total volume of water (litres per week)
Fruits	1kg	118	118000	2269.231
Vegetables	1kg	52	52000	1000
Cereal products	1kg	180	180000	3461.538
Starchy roots	1kg	31	31000	596.1538
Coffee	1cup	86	86000	1653.846
Tea	1cup	13	13000	250
Meat	1kg	461	461000	8865.385
Dairy products	1kg	78	78000	1500
Egg	1egg	25	25000	480.7692

Source: UNESCO-IHE Institute for Water Education, Water Footprint Network

Annex A2: Parameters for some home elements

WASH BASIN				
Open Faucet				**Unit**
Yes		No		
Normal		Saver		
10		3		L
SHOWER				
Type	**Selection 'Open tap'**			**Unit**
	Yes	**No**		
Local	14	7		L/min
Modern	12	6		L/min
WASHING MACHINE				
Digital Machine				**Unit**
Half full		**Full**		
25		50		L/washed
VEHICLE WASH				
Element	**Little**	**Medium**	**Big**	**Unit**
Car wash	75	145	250	L

Source: Field Survey, 2024

Annex B: Tables of questions with equations to quantify the blue, green and gray water footprint

In Annex 1 (blue water footprint); Annex 2 (green water footprint) and Annex 3 (Gray water footprint) the questions related to the different water footprints are reflected, which were asked to the inhabitants of the study area, through the survey as can be seen in Annex c.

Annex 1. Format to quantify blue water footprint

Nº	Ask	Question type	Unit	Rationale for the question
PERSONAL INFORMATION				The questions that include personal information are individual, open and specific to the respondent. This can cause the variance of the data obtained to be high since, due to the disposition of the respondent, erroneous answers can be generated.
1	What are your main sources of water?	Selection	……………	This help in identify respondents' sources of water
2	How many people live in your house?	Numeric	People/household	The specific value of people per household is needed
3	How many adult live with you?	Numeric	Type	This value is important to know the number of adults residing per house.
4	How many children live with you?	Numeric	Type	The water consumption data considers that children are in the age range of 0 to 12 years. In consumption data, children consume 50% of what an adult consumes.[1]
5	Level of education	Selection	………………	This data is important to determine if their education affect how they utilize water.
6	Years of farming experience	Numeric	………………	This value is important to determine if experiences contributes to water usage
FEEDING				Water that is consumed directly and indirectly in food, so it is essential to ask questions of this type to know the value of blue and green water.
7	How many litres of water do you consume per day?	Multiple choice	L/day	To calculate (L/month) with equation 5 = (L/day) x (30days/month)
8	How many liters of water do you use for cooking per day?	Multiple choice	L/day	To calculate (L/month) with equation 6 = (L/day) x (30days/month)

1. Adapted in Parra-Orobio et al. (2023). Assessment of the water footprint in low-income urban neighborhoods from developing countries: Case study Fátima (Gamarra, Colombia)

Annex. 2 Format to quantify green water

How many kilos of the following foods do you buy for your home per week?				
N°	**Ask**	**Question type**	**Unit**	**Rationale for the question**
9	Fruits	Numeric	Kg/week	To calculate (L/month) with equation 7. **Equation (7)** = (kg/week) x (L/kg) x (4weeks/month)
10	Vegetables	Numeric	Kg/week	
11	Cereal products	Numeric	Kg/week	
12	Starchy roots	Numeric	Kg/week	
13	**Drinks** How many cups of coffee do you take per day? How many cups of tea do you take per day?...........................	Numeric	Cup/day	To calculate (L/month) with equation 8. **Equation (8)** = (Cups/day) x (L/cup) x (30days/month)
14	Meat products	Numeric	Kg/week	To calculate (L/month) with equation 9. **Equation (9)** = (kg/week) x (L/kg) x (4weeks/month)
15	Dairy products	Numeric	Kg/week	
16	How many eggs do you buy at home per week?	Numeric	Numbers of eggs/week	

Annex 3. Format to quantify gray water

N°	**Ask**	**Question type**	**Unit**	**Rationale for the question**
PERSONAL CLEANLINESS				The personal hygiene aspect was considered only for hand washing, face washing, shaving and brushing teeth either with or without a sink.
17	Do you have a sink?	Selection	……..	If the answer is Yes, question No. 18 to No 23 is answered. Otherwise, go to No. 24.
18	How many times do you brush your teeth a day?	Numeric	Tooth brushing/ day	To calculate (L/month) with equation 10. **Equation (10)** = (Tooth brushing/ day) x (L) x (Adult/children) x

				(30days/month)
19	How many times do you wash your hands per day?	Multiple choice	Handwashing/day	To calculate (L/month) with equation 11. **Equation (11)** = (Handwashing/day) x (L) x (Adult/children) x (30days/month)
20	How many times do you wash your face per day?	Multiple choice	Facewashing/day	To calculate (L/month) with equation 12. **Equation (12)** = (Face washing/day) x (L) x (Adult/children) x (30days/month)
21	How many people shave their faces at home?	Numeric	………………	To calculate (L/month) with equation 13. **Equation (13)** = (Shave per week) x (L) x (Number of people Shaving) x (4weeks/month)
	How many times do they shave a week?	Multiple choice	Shave per week	
22	Do you leave the tap running when you brush your teeth and shave?	Selection	………………….	**The results depend on Annex A.**
23	Do you have a water saving-system installed in your sink?	Selection	………………	Calculation parameters: Personal hygiene in sinks
24	How many times do you brush your teeth a day?	Multiple choice	Toothbrushing/day	To calculate (L/month) with equation 14. **Equation (14)** = (Toothbrushing/day) x (L) x (Adult/children) x (30days/month)
	How many liters of water do you think you use per day brushing your teeth?	Multiple choice	L/day	
25	How many times do you wash your hands per day?	Multiple choice	Handwashing/day	To calculate (L/month) with equation 35. **Equation (15)** = (Handwashing/day) x (L) x (Adult/children) x (30days/month)
	How many liters of water do you think you use per day to wash your hands?	Multiple choice	L/day	

26	How many times do you wash your face per day?	Multiple choice	Facewashing/day	To calculate (L/month) with equation 16. **Equation (16)** = (Facewashing/day) x (L) x (Adult/children) x (30days/month)
	How many liters of water do you think you use per day to wash your face?	Multiple choice	L/day	
27	How many people shave their faces at home?	Numeric	……………..	To calculate (L/month) with equation 17. **Equation (17)** = (Shave per week) x (L) x (Adult/childre) x (4weeks/month)
	How many times do they shave a week?	Multiple choice	Shave per week	
	How many liters of water do you think you use to shave their face?	Multiple choice	L/day	
28	Do you have a shower?	Selection	…………………	If answer is yes, continue answering questions No 28, otherwise No 29
	What kind of shower do you have?	Multiple choice	…………………	**The result depends on Annex A.**
	How many times do you shower per day?	Multiple choice	Shower/day	To calculate (L/month) with equation 18. **Equation (18)** = (Shower/day) x (Mins/day) x (L/mins) x (Adult/children) x (30days/month)
	How many minutes does it last in the shower?	Multiple Choice	Min/day	
	Do you leave the faucet running while you bathe?	Simple selection	…………………..	
29	How many times do you bathe in a day?	Multiple choice	Baths/day	To calculate (L/month) with equation 19. **Equation (19)** = (Baths/day) x (L) x (Adult/children) x (30days/month)
	How many liters of water do you think you use when you bathe?	Multiple choice	L/day	
30	How many times a day do you use the toilet? How many litres of water do you use when you use the toilet?	Numeric Numeric	Times/day Average liter/day	To calculate (L/month) with equation 20. **Equation (20)** = (Times/day) x (average L) x (Adult/children) x (30days/month)
				To clean the house, different

CLEANING				elements are used daily that generate a certain gray water, which is why it is important to ask the following questions.
31	How many times a week do you clean your home?	Numeric	Times per week	To calculate (L/month) with equation 21. **Equation (21)** = (Times per week) x (No. of buckets) x (L/bucket) x (4weeks/month)
	When you clean your home, how many buckets of water do you think you used?	Multiple choice	Buckets	
	How many litters is the bucket?	Numeric	L/bucket	
32	What kind of washing machine do you have?	Multiple choice	………………	**The results depend on Annex 1**
	How many times a week do you use the washing machine?	Multiple choice	Laundry/week	To calculate (L/month) with equation 22. **Equation (22)** = (Laundry/week) x (No. of buckets) x (L/wash) x (2 cycle) x (4weeks/month)
	What capacity do you fill your washing machine to?	Multiple choice	………………..	**It depends on Annex A.**
33	How do you wash your dishes?	Multiple choice	……………..	If the answer is Yes, continue answering question No. 33, otherwise No. 34
	How many times do you wash your dishes in the dishwasher?	Multiple choice	Dishwashing/day	The deductions depend on Annex A. To calculate (L/month) with equation 23. **Equation (23)** = (Dishwashing/day) x x (L/mins) x (mins) x (30days/month)
	How long does it take to wash the dishes?	Numeric	Minutes	
	When you wash the	Selection	………………..	It depends on Annex 1.

	dishes, do you leave the tap running?			
	Do you have an energy saving system installed in your dishwasher?	Selection	……………………	
34	How many times a day do you wash your dishes?	Multiple choice	Dishwashing/day	To calculate (L/month) with equation 24. **Equation (24)** = (Dishwashing/day) x (L/day) x (30days/month)
	How many litters of water do you think you use per washing of dishes?	Multiple choice	L/day	
AGRICULTURE WATER CONSUMPTION				It is essential and independent to ask the following questions because they allow us to obtain agricultural water consumption
35	What is the total area of your cultivated land?	Numeric	Hectares	
	What type of crop watering do you use?	Selection	………………….	This question is important to determine crop irrigation methods
	What is the average total volume of water used per irrigation cycle?	Numeric	L/irrigation cycle	To calculate (L/month) with equation 25. **Equation (25)** = (Irrigation/day) x (L/irrigation cycle) x (30days/month)
	How many times do you irrigate your farm per day?	Numeric	Irrigation/day	
36	Do you have pets/livestock? If yes, please specify the types and numbers of livestock/pets you own?	Multiple choice	………………….	
	What is the estimated daily water consumption per head for each type of livestock? Cattle…………… Sheep …………...	Numeric	Liters/head	To calculate (L/month) with equation 26. **Equation (26)** = (Numbers of livestock) x (Liters/head) x (30days/month)

	Goats …………… Pigs……………… Poultry………….. Dog……………… Cat………………			
37	How many litres of water is used to clean livestock/pet house and equipment per week?	Numeric	L/week	To calculate (L/month) with equation 27. **Equation (27)** = (L/week) x (4weeks/month)
38	Do you have a vehicle?	Selection	…………………..	If the answer is not Yes, questions No. 39 to No. 40 are omitted.
39	What kind of vehicle?	Selection	…………………..	The results depend on Annex 1.
40	How many vehicles do you own?	Numeric	…………………..	
41	Does someone else wash your vehicle?	Selection		
42	What do you wash your vehicle with?	Selection		If another person wash your vehicle in a car was, please select ‘’Pressure washer’’ in question No. 42.
43	How long does it take to wash your vehicle?	Multiple choice	Minutes	To calculate (L/month) with equation 28. **Equation (28)** = (No. of Veh) x (Wash/month) x (L /minutes) x (Duration of wash/mins)
	How many times do you wash your vehicle per month?	Simple numerical selection	Wash/month	
44	How many buckets of water do you use to wash your vehicle?	Multiple choice	Buckets/vehicle	To calculate (L/month) with equation 29. **Equation (29)** = (No. of Veh) x (No. of buckets/veh) x (L /bucket) x (No. of wash/month)
	How many litters is the bucket?	Multiple choice		
	How many times do you wash your vehicle per month?	Multiple choice		

Anex C: Household questionnaire used in the present study

University of Novi Sad
Faculty of Agriculture and Environmental Sciences
Department of Water Management

Dear Esteemed Participant,

Thank you for taking the time to participate in this important survey on the water footprint of agricultural households. Your responses are invaluable and will contribute significantly to our research on understanding water use and its impacts in agricultural settings.

Purpose of the Research is to understand how water is used in various farming households' activities, identify patterns and practices that contribute to high water consumption.

Your participation is crucial because: As someone involved in agricultural activities, your firsthand experiences and knowledge provide unique insights that cannot be obtained from other sources. Accurate data from a variety of households helps us to create a comprehensive picture of water use in agriculture. The findings from this research can inform policies and practices that support sustainable water use, benefiting both current and future generations of farmers.

We assure you that all information you provide will be kept confidential and used solely for research purposes. Your responses will be anonymized, and no personally identifiable information will be shared with any third parties.

Please answer all questions to the best of your ability. If you are unsure about any question, feel free to provide your best estimate or skip it if necessary. There are no right or wrong answers.
We deeply appreciate your time and effort in contributing to this research. Your input is vital for understanding and improving water management in agricultural households.

Thank you for your participation and cooperation.

Sincerely,
David John Okoronkwo

SECTION A: QUESTIONS RELATED TO THE BLUE WATER FOOTPRINT

Location of the interview: Urban [ ] Rural [ ]

1. What are your main sources of water? Well [ ] Rainwater [ ] Community Stream [ ] Borehole [ ] River [ ]
2. How many people live in your house? …………………..
3. How many adult live with you? ………………………
4. How many children live with you? …………………..
5. Level of education: No formal education [] Primary [] Secondary [] Tertiary []
6. Years of farming experience……………………

FEEDING

7. How many litres of water do you consume per day? 1L…2L…3L …4L…5L…
   How many litres? ……………
8. How many litres of water do you use for cooking per day? …6L …8L ….10L … 12L
   How many litres?

Questions related to green water footprint

Per week how many kilos of the following foods do you buy for your home?

9. Fruits:

   Banana/plantain..………………………………………kg
   Orange ………………………………………….....kg
   Watermelon …………………………………………… kg
   Avocado ………………………………………………..kg
   Pineapple ……………………………………...…..kg
   Pawpaw ………………………………………………..kg
   Total: ………………………

10. Vegetables

   Tomatoes……………………………………………………..kg
   Bitter leaf……………………………………………………..kg
   Ugwu ………………………….…………………………..kg
   Carrot ………………………………………………………….kg
   Total: ………………………

11. Cereal products

   Maize ……………………………………kg
   Wheat …………………………………..kg
   Rice ………………………………………kg
   Sorghum ………………………………..kg
   Millet…………………………………….kg
   Total: ………………………

12. Starchy roots

   Potatoes…………………………………kg
   Cassava …………………………………kg
   Yam……………………………………...kg
   Coco yam ……………………………….kg
   Total: ………………………

13. Drinks

   How many cups of coffee do you take per day?......................
   How many cups of tea do you take per day?..........................

14. Meat products
   Chicken meat ……………………….…kg
   Pork …………………………………kg
   Beef …………………………………kg
   Fish ………………………………….kg

Total: ………………………

15. Dairy products
    Milk…………………………………kg
    Yogurt……………………………….kg
    Cheese………………………………kg
    Butter ……………………………….kg
    Total: ………………………

16. How many eggs do you buy at home per week? …4 …7 …9 …15 How many eggs …….

QUESTIONS RELATED TO GRAY WATER FOOTPRINT

Personal Cleanliness

17. Do you have a sink? …Yes …No

    If the answer is Yes, question No. 18 to No 23 is answered. Otherwise, go to No. 24.

18. How many times do you brush your teeth a day? 1… 2… 3… 6…
    How many times do you brush per day? ……….

19. How many times do you wash your hands per day? 4…. 5….. 6…. 7…
    How many times do you wash your hands per day?.........

20. How many times do you wash your face per day? ….1 ….2 …3… 4….
    How many times do you wash your face per day? ……………

21. How many people shave their faces at home? …………
    How many times do they shave a week? 0… or 1…..
    How many times a week? ……..

22. Do you leave the tap running when you brush your teeth and shave? Yes…. No….

23. Do you have a water saving-system installed in your sink? Yes or No

24. How many times do you brush your teeth a day? 1… 2… 3… 6…
    How many times do you brush per day? ……….
    How many liters of water do you think you use per day brushing your teeth? 1.25L …. 2.5L …. 3.7L… 5L …. How many liters? ……..

25. How many times do you wash your hands per day? 4…. 5….. 6…. 7…
    How many times do you wash your hands per day?.........
    How many liters of water do you think you use per day to wash your hands? 3.75L …. 5L …. 7.5L… 10L …. How many liters? ……..

26. How many times do you wash your face per day? ….1 ….2 …3… 4….
    How many times do you wash your face per day? ……………

How many liters of water do you think you use per day to wash your face? 2.5L …. 5L …. 7.5L… 10L …. How many liters? ……..

27. How many people shave their faces at home? ………… How many times do they shave a week? 0… or 1….. How many times a week? ……..
    How many liters of water do you think you use to shave their face? 2.5L …. 5L…. How many liters? ……..

28. Do you have a shower? Yes or No

    If answer is yes, continue answering questions No 28, otherwise No 29

    What kind of shower do you have? Local [ ] or Modern [ ]
    How many times do you shower per day? 1… 2… 3… 4…. How often?
    How many minutes does it last in the shower? 3… 4… 5… 7…. How many minutes?.......................................
    Do you leave the faucet running while you bathe? Yes or No

29. How many times do you bathe in a day? 1… 2… 3… 4… 5… How often?
    How many liters of water do you think you use when you bathe? 11L… 22L… 33L… 44L… How many liters?
30. How many times a day do you use the toilet? …………..
    How many litres of water do you use when you use the toilet?....................

CLEANING

31. How many times a week do you clean your home?........
    When you clean your home, how many buckets of water do you think you used? 7… 8… 9…15 How many buckets….
    How many litters is the bucket? 11L…. 15L… 20L… 25L… How many litters?.... L

32. What kind of washing machine do you have? Manual [ ] or Digital [ ]
    How many times a week do you use the washing machine? 1… 2… 3… How many times?….
    What capacity do you fill your washing machine to? Full [ ] or Half full [ ]
33. What do you wash your dishes in?
    Dish washer? Yes or No …. Which one?..........

    If the answer is Yes, continue answering question No. 33, otherwise No. 34

    How many times do you wash your dishes in the dishwasher? 3… 4…5… how much? …..
    How long does it take to wash the dishes? ………………….. minutes
    When you wash the dishes, do you leave the tap running? Yes [ ] or No [ ]
    Do you have an energy saving system installed in your dishwasher? Yes [ ] or No [ ]

34. How many times a day do you wash your dishes? 3… 4… 5…. How much? ……..
    How many litters of water do you think you use per washing of dishes? 15L …. 20L …25L …30L …. How many? ……….L

AGRICULTURE WATER CONSUMPTION

35. What is the total area of your cultivated land?............................ha

What type of crop watering do you use? Rain [ ] Irrigation [ ] Mixture of Rain and Irrigation
What is the average total volume of water used per irrigation cycle? 50L… 100L… 200L… 300L… How many litres………………
How many times do you irrigate your farm per day? 1… 2…. 3…. How many…..

36. Do you have pets/livestock? Yes or No

    If yes, please specify the types and numbers of livestock/pets you own?
    Cattle…………………………
    Sheep ………………………...
    Goats …………………………
    Pigs……………………………
    Poultry ………………………..
    Dog……………………………
    Cat…………………………….

    What is the estimated daily water consumption per head for each type of livestock?
    Cattle…………………………. Liters/head
    Sheep ………………………… Liters/head
    Goats ………………………… Liters/head
    Pigs ………………………… Liters/head
    Poultry…………………………. Liters/head
    Dog …………………………….. Liters/head
    Cat ……………………………… Liters/head

37. How many litres of water is used to clean livestock/pet house and equipment per week?............

38. Do you have a vehicle? Yes [ ] or No [ ]

    If the answer is not Yes, questions No. 39 to No. 40 are omitted.

39. What kind of vehicle? Little [ ] Medium [ ] Big [ ]
40. How many vehicles do you own? 1… 2… 3… 4… How many?...........
41. Does someone else wash your vehicle? Yes or No

    If another person wash your vehicle in a car was, please select ‘’Pressure washer” in question No. 42.

42. What do you wash your vehicle with? Bucket [ ] Hose [ ] Pressure washer [ ]

    If the answer is with a bucket, skip question No. 43

43. How long does it take to wash your vehicle? 15mins… 20mins… 25mins…30mins …. How many?..... minutes
    How many times do you wash your vehicle per month? 3.. 4… 5… 6… How many?....
44. How many bucket of water do you use to was your vehicle? 5… 7… 8 …..15 How many buckets?........
    How many litters is the bucket? 11L… 15L…. 20L… 25L…. How many litters? …….L

How many times do you wash your vehicle per month…. 3… 4 …5 …6…. How many times?.....

SECTION B: ACTIVITIES ASSOCIATED WITH HIGH INTRA-HOUSEHOLD WATER USE

Please, tick the response options that best applies to you

Code	**Variable**	**Strongly disagree (1)**	**Disagree (2)**	**Neutral (3)**	**Agree (4)**	**Strongly Agree (5)**
P1	I leave the tap running when taking a shower					
P2	I leave the tap running when brushing teeth					
P3	I use large amount of water to reduce dust in the street					
P4	I leave the tap running when washing dishes					
P5	I do not have water-saving devices					
P6	I use water irrationally					
P7	Excessive irrigation of farmlands					
P8	I wash clothes excessively					
P9	I do not re-use water					
P10	I have large household size					
P11	Lack of household water metering					
P12	Lack of inspection and maintenance of household pipes					
P13	Lack of rainwater harvesting					
P14	I cultivate large farmland					
P15	Planting high-water demand crops					
P16	Lack of water saving irrigation system					
P17	Receiving lesser amount of rainfall than usual					
P18	I have large amount water of livestock					
P19	Poor storage of water in open tanks					
P20	Lack of knowledge on how to reuse wastewater					