

International Journal of Development and Sustainability
ISSN: 2186-8662 – www.isdsnet.com/ijds
Volume 14 Number 6 (2025): Pages 336-356
https://doi.org/10.63212/IJDS24092301

Coping with water, energy, and food challenges: A case study of low-income households in Soweto, South Africa

M. Togo, C.P. Gandidzanwa *, M. Mogashoa

Department of Environmental Sciences, University of South Africa, Johannesburg, South Africa

Abstract

Rapid population growth and the climate change crisis exert significant pressure on resources, including water, energy, and food (WEF). Providing these essential resources amidst increasing demand presents a substantial challenge for local governments in developing countries. Current strategies of coping with these resource shortages in a household context are creating more challenges concerning human health and the environment. The interdependence and interactions between WEF systems necessitate an integrated management approach in investigating ways of ensuring their sustainable provision. This study analyses the state of WEF provisioning, the challenges faced, and the coping strategies among low-income households in Soweto. Data was collected through a survey. Questionnaires were administered to 486 households to establish the sources of WEF, challenges, and coping methods. The research is informed by Lazarus and Folkman's Transactional Model of Stress and Coping, which evaluates the processes of coping with stress in the context of WEF. Findings revealed water-energy supply interruptions and increasing electricity and food costs, among other challenges. Various coping strategies adopted by households include buying bottled water, storing water in plastic buckets, using gas and wood fuel for cooking, staying outside during loadshedding until electricity is restored, and buying cheap foodstuffs. The provision of safe, reliable, and sustainably managed WEF resources is urgently needed in the area for both environmental and human well-being. Sensitizing the community on water-energy conservation measures reduces carbon emissions, saves water and energy, boosts financial savings, and bolsters households' food security. Insights from this study can assist policymakers in identifying sustainable practices for addressing the complex challenges faced in WEF provisioning. The integration of WEF management policies can also foster the sustainability of policies.

Keywords: Water, Energy, Food; Coping Strategies; Emotion-Focused Coping Strategies; Problem-Focused Coping Strategies; Urbanisation; Climate Change

Published by ISDS LLC, Japan | Copyright © 2025 by the Author(s) | This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.



Cite this article as: Togo, M., Gandidzanwa, C.P. and Mogashoa, M. (2025), "Coping with water, energy, and food challenges: A case study of low-income households in Soweto, South Africa", *International Journal of Development and Sustainability*, Vol. 14 No. 6, pp. 336-356.

* Corresponding author. *E-mail addresses:* gandicp@unisa.ac.za, pamigandi@gmail.com

1. Introduction

Africa's population, currently at 1.1 billion, is projected to double by 2050, with over 80% of the people residing in urban areas, including informal settlements (Simpson et al., 2023). With a projected global temperature increase of 4.8°C by 2100, frequent and severe weather events such as drought and heatwaves will continue to affect energy generation and food production (Gao et al., 2024). Climate models have shown that an increase in heatwaves and regional warming under low mitigation measures is likely to make Southern Africa generally drier. These impacts are affecting countries such as South Africa with extraordinary impacts, such as the possibility of "day-zero" (a high level of water restrictions) in the Gauteng province (Engelbrecht et al., 2024). The Intergovernmental Panel on Climate Change (IPCC) Special Report declared Southern Africa a hotspot regarding climate change (Engelbrecht et al., 2024). The interconnectedness of WEF resources amidst severe climate change-induced problems and a rapidly growing population is becoming more apparent (Rai, 2023). The siloed approaches to managing WEF have failed to address the societal grand challenges. Furthermore, most of the studies that used the WEF nexus framework have been at a scale larger than individual households. There is a paucity of data on how urban households in low-income areas cope with WEF challenges, which this study focuses on. Investing in sustainable WEF management is urgently needed to improve WEF provisioning among urban households without compromising environmental well-being.

Studies in India, Tanzania, Malawi, South Africa, and Zimbabwe confirm challenges of service provision among low-income communities (Vidhyadharan, 2023; Kabote, 2024; Price et al., 2021; Adom et al., 2022; Gandidzanwa and Togo, 2023). Improvements in WEF provisioning are central to the African Union's Agenda 2063 (Simpson et al., 2023). Despite this vision, access to safe and adequate water, affordable energy, and healthy food remains a challenge for many urban households, especially in vulnerable communities in developing countries. These issues of access are increasingly becoming governance challenges (Caputo et al., 2021). Progress in water provisioning is often hampered by resource constraints, lack of capacity, inadequate skills, poor revenue collection, and uncoordinated policies (Adom and Simatele, 2024).

Households sometimes resort to alternative water sources besides the municipality due to convenience, seasonality, or individual choice (Adams et al., 2020). Even in urban areas with piped water, water insecurity persists in countries like Malawi, India, Nigeria, Tanzania, Zimbabwe, and Uganda (Adams et al., 2020; Vidhyadharan, 2023; Kabote, 2024; Gandidzanwa and Togo, 2023; Mguni et al., 2020). A study by Oyerinde and Jacobs (2024) in Southwest Nigeria found that households use 15 different water sources. In Kampala, Uganda, Tumwebaze et al. (2023) found an association between the use of alternative water sources and water service levels. In terms of energy, globally, 2.8 billion people use dirty fuels that pose health hazards and environmental harm (Perros et al., 2023). Power shortages in countries such as Zimbabwe, South Africa, Zambia, and Tanzania are due to aging infrastructure, excessive pressure, overreliance on hydroelectric power, and the impacts of droughts, which all exacerbate electricity shortages (Gandidzanwa and Togo, 2023; Chiwaridzo, 2024). In South Africa and Zambia (Price et al., 2021), Uganda (Mguni et al., 2020), Kenya (Perros et al., 2023), Ethiopia (Tucho et al., 2022), Nigeria (Megbowon et al., 2018), Zimbabwe (Makonese et al., 2017), and Tanzania (Kitole et al., 2023), most households use a fuel-stacking model where both clean and dirty fuels are part of the household energy mix. Despite Nigeria's status as an energy giant, most households depend on fuelwood for domestic purposes (Ogujiuba and Muazu, 2022). In Kenya and Uganda, illegal connections are common due to unaffordable charges (Njoroge et al., 2020; Mguni et al., 2020), especially because there is a direct association between energy use patterns and poverty (Kitole et al., 2023). Increasing awareness of the

benefits of energy-efficient appliances is also driving other coping mechanisms (Fatoki et al., 2020; Olatunde et al., 2024). Studies in Zimbabwe, Kenya, Uganda, Malawi, and Nepal have revealed an increase in urban agriculture as a source of livelihood, highlighting challenges in food access, quality, and affordability among the urban poor (Kimani-Murage et al., 2015; Tacoli, 2019; Tevera, 2023; Kanosvamhira, 2024).

South Africa, just like any other developing country, is suffering from the severe impacts of climate change and deteriorating urban infrastructure that cannot sustain the current urban population growth. The country experiences low rainfall and has low per capita water availability (Adom et al., 2022). Johannesburg experienced intermittent water supplies for a period of about 3 to 4 years (Sheridan et al., 2024). For example, between 2023 and 2024, the highly elevated old suburbs, including Soweto, were water insecure due to regular intermittent water supplies (Sheridan et al., 2024). The water outages were due to ongoing maintenance of the water pipes, which kept bursting. Repaired pipes often continue leaking due to minimum maintenance standards (Sheridan et al., 2024). Of all the water allocated to Gauteng, almost 50% is lost through theft and/or leaking pipes (Sheridan et al., 2024). The system is overloaded by the high-water demand, which outstrips supply, especially with the added challenge of loss of water due to leakage/theft. This results in the drawdown on potable water reservoirs surpassing the rate of recharge (Sheridan et al., 2024). As reservoirs get empty during high-demand periods, the city of Johannesburg regulates the supply, leaving most households without water for some time.

South Africa is one of nine countries operating the longest-running Energy Efficiency Standards and Labelling (EES and L) programs (Vérez et al., 2022). However, the national energy grid has collapsed, which has led to nationwide power blackouts that affect households' daily activities like food access, preparation, and storage, especially in urban areas (Masuku, 2024). The situation is particularly so for low-income households in Johannesburg, where factors such as unaffordable energy costs, load-shedding, and lack of knowledge on running energy-saving homes have worsened energy poverty (Masuku, 2024). Although 87% of households have electricity access, affordability remains a challenge (Oyekale and Molelekoa, 2023). Despite 89 % of households being connected to the national electricity grid in South Africa in 2021, not all the electrified households used electricity for cooking (Wernecke et al., 2024).

Gulati et al. (2013)'s study in South Africa highlighted that water and energy systems significantly impact the availability, quality, and affordability of food, while rising food prices also affect energy and water costs. This interlinkage was supported by Allouche et al. (2015), who observed a strong correlation between food and energy crises. Nenguda and Scholes (2022) attributed food price increases in South Africa's peri-urban areas to drought. While initiatives like school feeding schemes and social grants have somewhat alleviated food insecurity, they have not managed to address emergent expenses such as increased energy bills. Despite global discussions on the just energy transition, relevant water issues remain unaddressed in South Africa and other Southern African countries' energy policies. Similarly, water pricing policies in South Africa do not account for energy costs (Gulati et al., 2013). The role of energy poverty in dietary choices is also not addressed, yet research has established that households choose foods that require less cooking time, potentially affecting dietary diversity due to energy poverty (Ningi et al., 2021). Understanding these household challenges in Soweto is crucial in selecting appropriate coping strategies that enhance the greening of households for sustainable development.

This study contributes to the existing literature by highlighting how households cope with WEF challenges in cities. The WEF nexus, which originated as a security tool to manage resource scarcity, is still in its infancy

in South Africa (Adom et al., 2022). The demand side of WEF resources tends to be overlooked, yet some WEF management practices can result in air pollution and health issues (Makonese et al., 2017). WEF nexus shortages and insecurities threaten sustainability in urban areas. There is a dearth of information on how WEF insecurities intertwine with livelihoods at the household level (Biggs et al., 2015). This study focuses on establishing WEF nexus insecurities and coping strategies in Soweto to promote green households through fostering integrated WEF nexus approaches.

2. Methodology

2.1. Theoretical framework

To understand the WEF stresses/insecurities and coping strategies, the research is informed by Lazarus and Folkman's Transactional Model of Stress and Coping (TMSC). Lazarus and Folkman developed the Transactional Model of Stress and Coping in 1984 to help people cope with stressful situations using the objective appraisal. The framework evaluates the processes of coping with stress (Burton et al., 2020). The linear progression model can be broken down into three stages; primary appraisal, the impact of stress on one's well-being; secondary appraisal, the available resources that enable one to cope with the stress and use of coping strategies, which might include problem-based strategies or emotion-based strategies (Burton et al., 2020). Problem-focused coping comprises strategies that involve practical, action-based tools that allow one to act on the environment or cognitive reasoning (Folkman and Lazarus, 1985). It involves strategies that control one's stressful emotions. Emotion-focused coping can be positive or negative. It can be positive, for example, seeking emotional or moral support, and can stimulate negative behaviour or feelings such as self-blame, frustration, anger, and avoidance. Figure 1 shows the framework model within the context of WEF.

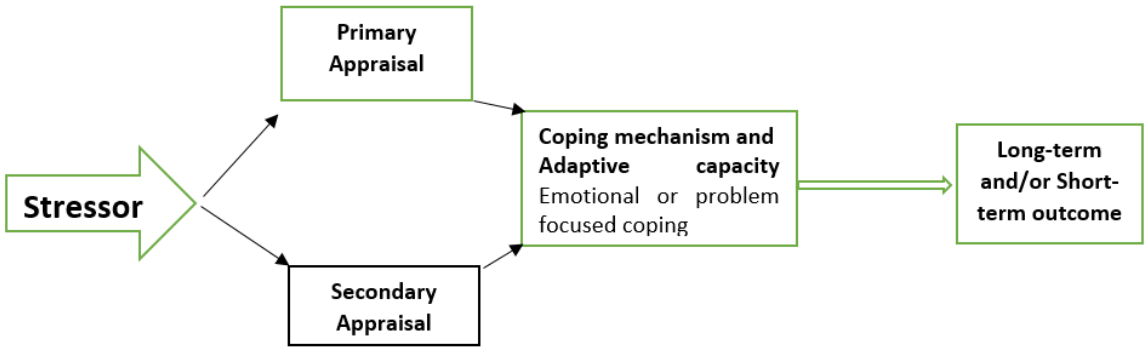


Figure 1. The Transaction Model of Stress and Coping, adapted from Lazarus and Folkman (1987)

In the context of WEF, the stressor is the relationship between the household and access to WEF resources and the challenge of coping with the scarcities. Stress arises when the demands of a situation exceed one's coping capacity. Coping processes are moderators between environmental impacts and environmental consequences (Folkman and Lazarus, 1985). In this study, coping mechanisms used by households in response

to WEF challenges can either inhibit or foster environmental sustainability. An insight into people's motives, attitudes, behaviours, beliefs, and intentions will help to inform policy. Inadequate and uneven WEF provisioning sheds light on deeply rooted inequalities, particularly for vulnerable people in Soweto.

2.2. Study area

The research was conducted in three distinct residential areas (Dobsonville, Meadowlands, and Mofolo North) within the Soweto township. Dobsonville borders Mofolo North and Zondi in the Southern part of Soweto and is located to the west of Meadowlands. Meadowlands is in the northern portion of Soweto. In all the research areas, households in the formal settlements have indoor taps, and those that are not part of the formal sections access water from the communal taps. Soweto is recognized for its established communities and socioeconomic and cultural diversity, yet it remains one of the most notable historically disadvantaged townships (Mukoma et al., 2023) characterized by higher levels of population vulnerability (Hopkins et al., 2019).

Water supply interruptions and energy challenges experienced in the area, coupled with low household income, make Soweto a relevant study area to explore the potential for addressing these challenges based on a nexus approach. Johannesburg faces considerable water challenges, which often prompts authorities to implement water restrictions to manage demand (Murwirapachena, 2021). Additionally, household food insecurity has persisted in the Gauteng City Region from 2000 to 2020 (Mazenda et al., 2022). Like any other megacity in Africa, Johannesburg is experiencing other urbanisation challenges like poor living conditions, sanitation, and waste management. Figure 2 shows the location of Soweto and the study sites.

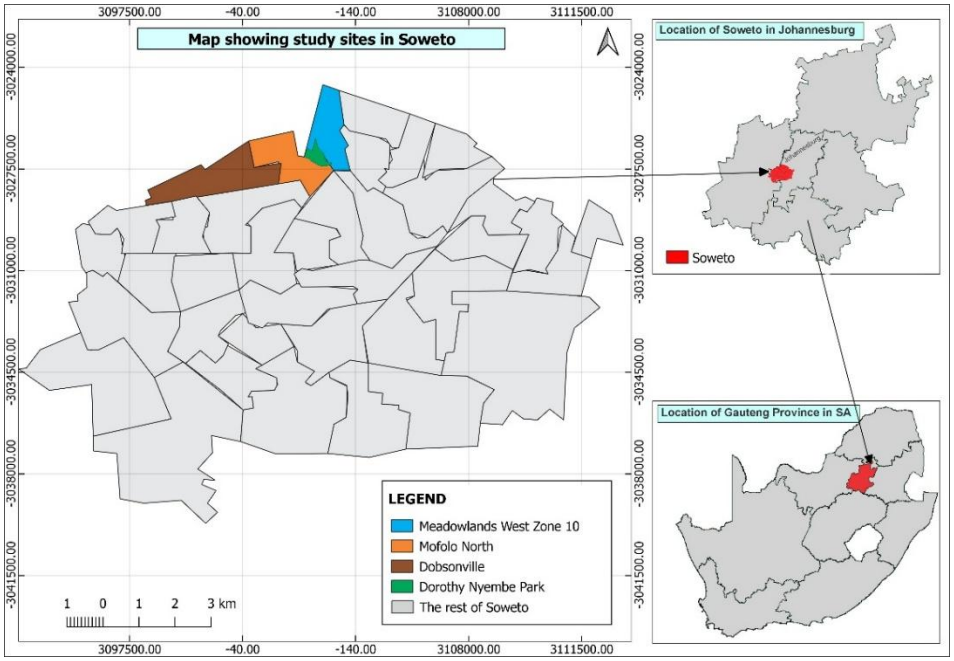


Figure 2. The location of study sites in Johannesburg

2.3. Research methods

A purposive sampling approach was used to select communities to be included in the research, and three communities were selected. Dorothy Nyembe Park served as a valuable starting point due to it being central to three residential areas, namely Dobsonville, Meadowlands, and Mofolo North.

For each of these communities, probability sampling was then applied to select households that formed part of the questionnaire survey. The sampling unit was a household. Questionnaire respondents were selected based on random sampling using a random number table. The cumulative population for these residential districts was 21,385 households based on the 2011 census. The Raosoft, online sample size calculator was used to determine the number of respondent households for the questionnaire administration. With a population of 21, 385 households, based on a confidence level of 95% and a 5% margin of error, the recommended sample size was 378 respondents. In this instance, a target of 500 household representatives between the ages of 18 and 65 years completed the questionnaire. From the expected 500 questionnaire responses, 486 cases were collected, and these correspond to a response rate of 97.2%. The sample size for this study was sufficient, and the findings were representative.

Based on the objectives and the scope of the study, the questionnaire was developed. This comprised a mix of open-ended and closed-ended questions to gather both quantitative and qualitative data. The study ensured that the questions covered key areas such as current WEF status, coping strategies, effectiveness of current policies and strategies, and suggestions for improvements. A pilot test was conducted to identify issues with question clarity or survey structure. The questionnaire was revised based on feedback from the pilot test to ensure it was easy to understand and complete.

This paper is based on the qualitative results from the questionnaire. Open-ended questions provided rich and elaborate qualitative data. In-depth insights into the complicated changing household consumption patterns, lifestyles, knowledge, and adaptive measures are crucial for effective policy in adaptation (Toole et al., 2016).

3. Presentation and discussion of findings

3.1. WEF provisioning

Results indicate that the provision of WEF in Soweto is characterized by significant challenges and systemic issues. The residential areas in which the research took place are high-density areas characterized by low incomes. The researched communities face acute pressures in managing WEF resources due to rapid urbanization, socioeconomic disparities, and infrastructural limitations. Figure 3 shows WEF provisioning challenges and coping mechanisms emerging from the findings.

As shown in Figure 3, WEF challenges include inadequate supplies of electricity, water, and food. Inadequate electricity supply is influenced by load shedding, cable theft and vandalism, and the high cost of electricity. Inadequate water supply is influenced by infrastructural challenges and a lack of municipal capacity to provide water. Inadequate food supply is mainly driven by the high cost of food items in food shops. Various coping mechanisms have been implemented to fortify communities against the WEF challenges. These include storing water in plastic buckets in response to water cuts, relying on gas and wood fuel for boiling water as a

coping mechanism to load shedding/power cuts and high electricity bills, and buying cheap and basic foodstuffs to cope with increasing prices for food.

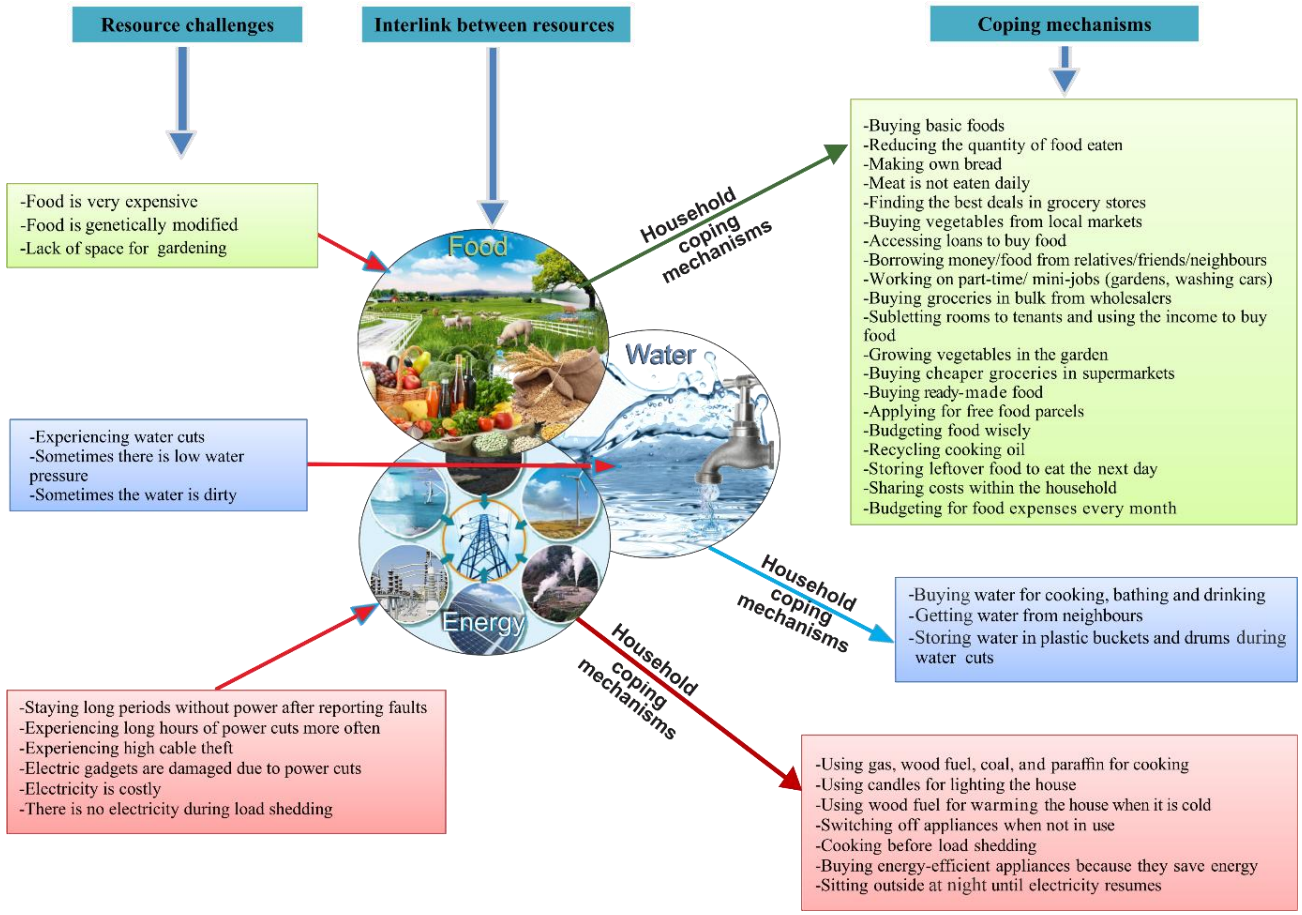


Figure 3. WEF challenges and coping mechanisms in Soweto

3.2. Water provisioning

The findings of this study indicate that households in Soweto rely heavily on the municipal water supply, which is often interrupted due to aging infrastructure, maintenance issues, and intermittent service delivery. Households raised concerns about water supply interruptions in the study sites. One resident said, "*We rely on piped water and sometimes experience water cuts. Sometimes water has low pressure".* This is the experience of many households in the study area. The reasons for this include water cuts, pipe bursts, or regular maintenance. These findings are affirmed in other studies in which it was observed that access to piped water does not always ensure a reliable supply of water (Adams et al., 2020; Tshililo et al., 2022). Some municipalities supply water intermittently as an adaptive mechanism in response to the increasing population and rising water demand (Li et al., 2020). This practice stems from technical, economic, and environmental insecurities and can

result in socioeconomic, health, and technical challenges (Zyoud, 2022). It also significantly hampers sanitation and hygiene efforts. Studies in Ghana, South Africa, and Uganda have confirmed water interruptions in households, forcing them to rely on stored water (Simelane et al., 2021; Tshililo et al., 2022; Tumwebaze et al., 2023; Abubakar et al., 2023).

During water outages, households rely on storing water in plastic buckets and drums, purchasing water for cooking and drinking, and obtaining water from neighbours, as illustrated in Figure 3. Households collect water when it is available and store it in buckets for use when there are water shortages. Water is also purchased from refilling stations or as bottled water from shops, though this can be an additional financial burden for households already experiencing food insecurity. According to Sheridan et al. (2024), despite the high cost of buying bottled/container water, sometimes households had no other option except to purchase water. Storing water or purchasing water can be regarded as emotionally focused coping strategies that help to deal with the emotional distress associated with intermittent water supply. Both can have negative emotional effects on residents (Folkman and Lazarus, 1985).

Where water pipes continue to leak due to poor/minimum maintenance, other households rely on collecting/stealing water from those leaking pipes to cope with water challenges. This was confirmed by Sheridan et al. (2024), who noted that, of the water allocated to Gauteng, almost 50% is lost through theft and/or leaking pipes. This reduces potable water in reservoirs, with water loss surpassing the rate of recharge (Sheridan et al., 2024). The city of Johannesburg will then end up being forced to throttle the water supply during high-demand periods, leaving most households without water for some time.

Residents frequently store large quantities of water in unsanitary storage containers, and this can pose health hazards. This practice was common in Ghana during the COVID-19 pandemic when increased water usage was necessary for hygiene purposes (Kumpel et al., 2021). However, there is a risk of consuming contaminated water, as stored water can easily become contaminated (Tshililo et al., 2022). Evidence has shown the presence of E. coli in water from storage devices. In Malawi, E. coli levels were noted in drinking water samples as households in slums resorted to alternative water sources (Price et al., 2021). There are also health risks associated with obtaining water from neighbours and purchasing water from untrustworthy vendors as coping measures. Even potable water has been reported to be dirty and unreliable in India, Malawi, and South Africa, compelling households to seek alternative sources (Adams et al., 2020; Vidhyadharan, 2023; Chitonge et al., 2020).

Despite the discussed challenges of water outages, some households in the study sites revealed that they do not face any water shortage challenges. They are connected to municipal piped water, which is a safe source of drinking water. The assertion by one of the respondents that "*I do not have any challenges regarding water*" reflects a situation reiterated by several households in the stated localities. Related past research in South Africa revealed that 92% of the urban population uses piped water and that over 91% of the population has access to safe drinking water sources (Oskam et al., 2021; WHO/UNICEF, 2015). This situation, however, differed from one town to another. For example, Tshililo et al. (2022) reported that only 62% of the households in Diepsloot Township have primary sources of water on their premises. Still, this is a high level of water security when compared to most cities in Sub-Saharan Africa that lack access to water service provisions and sanitation facilities (WHO and UNCF, 2017; Kim et al., 2022). The findings of this study resonate well with Simelane et al. (2021)'s results in SA and Eswatini, which confirmed that the countries are on track in terms of meeting SDG 6 targets, ensuring access to improved drinking water.

3.3. Energy provisioning challenges

It emerged from the findings that Soweto faces significant energy challenges. Frequent power and unscheduled power outages disrupt daily activities. This is exacerbated by dependence on an aging and overburdened electricity grid. Many households are unable to afford modern energy solutions, hence, they resort to the use of unclean energy sources like kerosene and firewood, which pose health and environmental risks. While renewable energy solutions such as solar power offer potential relief, their adoption is hindered by high initial costs and limited awareness. Integrated renewable energy systems within smart microgrids could provide a more reliable energy supply. However, such initiatives require substantial investment and policy support.

Respondents in the study indicated that they are connected to the grid network but experience frequent power outages, which can last for prolonged periods. In addition to that, load shedding is implemented on and off, and this has been the case for many years. The reasons for power outages were given as transformer failures, cable damage, and cable theft. Reports from respondents included statements such as:

- *"We do not have electricity when there is load shedding."*
- *"It's been over four months now without electricity."*
- *"We experience long hours of power cuts more often."*
- *"We have had no electricity since June due to the breakdown of the transformer."*

Accessing modern, affordable, reliable, and adequate energy is a significant challenge for most urban areas in developing countries (Houngbonon et al., 2021). Load shedding and power outages are prevalent across Africa (Blimpo and Cosgrove-Davies, 2019). In countries such as Zimbabwe, Uganda, Ghana, and Nigeria, over 50% of grid-connected households have power for only half a day or less (Blimpo and Cosgrove-Davies, 2019). In South Africa, load shedding significantly impacts most households, particularly those in low-income areas. These areas often have aging and less reliable infrastructure, hence, the breakdowns are frequent and prolonged (Inglesi-Lotz, 2023; Masuku, 2024). Cable theft, a growing crime in South Africa, often happens in low-income areas, leaving households without electricity for days (Mmakwena, 2022). In Kampala, Uganda, power cuts disrupt carpentry shop activities, which also reduce the production of timber off-cuts, which serve as one of the energy sources for households (Mguni et al. 2020). Power brownouts (a decline in voltage) and blackouts are also common, and they can be a deliberate measure to reduce the load or are a result of disturbances in the electrical grid system caused by events such as lightning strikes. Load shedding, power cuts, blackouts, and brownouts generally exacerbate the vulnerability of urban households where energy is concerned. Respondents reported damage to electronic gadgets due to power cuts, as sudden outages can cause voltage fluctuations and surges, damaging sensitive electronic components in appliances.

The cost of energy is a major concern among most urban households. Some residents receive Social Relief of Distress (SRD) and child support grants. The SRD is a financial assistance programme for the unemployed and vulnerable population in South Africa (Ndlovu and Masuku, 2024). The grants are not adequate to cover all the energy costs, and, hence, the respondents expressed concerns over high electricity bills.

Due to the gravity of the experienced challenges, residents have come up with different strategies for averting the energy shortages. The choice of coping mechanisms depends on the frequency and duration of interruptions and the available financial resources. Households in the study area opt for alternative energy sources, including gas, wood fuel, coal, candles, paraffin, and diesel/petrol-powered generators. Households

use multiple sources for different purposes, for example, gas for cooking, wood fuel for heating and warming, and candles for lighting. The respondents said:

- *"We use gas and candles to light up the house, keep warm, and cook."*
- *"I use my fireplace (wood) to warm up the home."*
- *"I use wood fuel for cooking and keeping warm."*
- *"We use gas for cooking and charging lights."*

Gas was the most prevalent alternative energy source for cooking. Gas is a relatively clean energy source. It is cheaper with relatively stable prices, unlike electricity, which is expensive and is subject to constant price hikes. Gas is also more efficient for cooking and can be easily accessed. These results confirm findings from the Statistics South Africa Census data, which revealed that electricity and gas are the primary energy sources for cooking and lighting, while candles and solar energy are used during load shedding (Cheruiyot et al., 2024). Coal, charcoal, and wood were also mentioned by the respondents as energy alternatives. South Africa is among the few countries where households still use coal for domestic purposes (Phogole et al., 2022). These results are comparable to previous research done by Masuku (2024) and Mohlakoana et al. (2019), which revealed that households sometimes use multiple fuel sources like LPG, charcoal, wood, and solar energy. Urban households in Southern Africa prefer wood and charcoal as alternative energy sources (Makonese et al., 2017; Megbowon et al., 2018; Mpandeli et al., 2018). These solid fuels are mostly used for cooking, space heating, and boiling water (Nkosi et al., 2021). Households that opt for portable generators use them for powering electric gadgets and lighting. Though generators are a potential backup, they are generally discouraged due to their contribution to greenhouse gas emissions (Hachem-Vermette and Yadav, 2023).

These results confirm the existence of energy poverty among some households where the energy is not adequate and is expensive. Programmes like the Free Basic Electricity (FBE) and Free Basic Alternative Energy (FBAE), which are meant to address energy poverty, have been criticized for poor administration. Moreso, they are being compromised by the recurrent blackouts, load shedding, and load reduction. Some households even resort to illegal grid connections to avoid high electricity bills, as noted by Masuku (2024) in his study in South Africa.

Other coping strategies that the respondents mentioned are:

- Switching off appliances that are energy-intensive, such as the geyser
- Using energy-efficient appliances because they don't use much energy
- Going next door to fetch water or cook
- Sitting outside the house until electricity is restored
- Cooking and taking meals before load-shedding

These strategies are a mix of energy efficiency practices and mechanisms to cope with energy shortages. Energy-efficient appliances not only conserve energy but also reduce carbon emissions and contribute to mitigating climate change (Olatunde et al., 2024). By saving energy, households can lower their expenses, save finances, and reduce their exposure to poverty (Olatunde et al., 2024). According to the Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report, energy-efficient appliances can significantly reduce electricity consumption, and South Africa is one of the nine countries with long-standing Energy Efficiency Standards and Labelling (EES andL) programmes (Vérez et al., 2022). Fatoki et al. (2020) emphasized the importance of raising awareness and enhancing knowledge about the benefits of energy-efficient appliances

in South Africa. Energy efficiency, however, leverages on and is anchored by the level of awareness among members of a household. The intention to purchase energy-efficient appliances, a problem-focused coping strategy, is influenced by cognitive reasoning and reflects an individual's pro-environmental behaviour. It involves managing the emotional stress associated with high energy bills.

Spending time outside the house until electricity is restored restricts cooking times and options and limits the opportunity for quality cooking. Cooking has therapeutic benefits and fosters social interaction and self-esteem (Ahmed, 2023). Restricted cooking choices can disrupt eating patterns, which can lead to malnutrition (Ahmed, 2023). Sitting outside the house when there is no electricity, especially at night, can be an emotional reaction aimed at alleviating the emotional distress caused by power outages, delayed cooking, late eating, and disrupted sleep. This helps with mental disengagement, which aids in normalizing an otherwise irregular situation. According to Folkman and Lazarus (1985), it reflects behavioural or mental disengagement tendencies, where there is decreased effort to cope with, or inability to address the stressor, such as load shedding or power cuts, signalling that the demands of the situation have exceeded one's coping capacity, resulting in a sense of helplessness. Consequent negative emotional effects include psychological stress, which is associated with altered sleeping patterns and malnutrition. Delayed cooking impacts food quality as well as the quantity of food that can be prepared (Branca et al., 2019).

The findings of this study are consistent with Ahmed (2023)'s research in Zambia, which observed changes in sleeping patterns due to severe power blackouts over the past six years. The El Niño droughts of 2015, 2016, and 2019 significantly affected Zambia, a country heavily reliant on hydropower. This exacerbated WEF nexus challenges. Water scarcity severely affects hydroelectric power generation, leading to load shedding and power outages, which in turn negatively impact cooking patterns, dietary diversity, and overall food security. The concerning reality is that vulnerable people, including the poor, suffer disproportionately from energy and energy-related challenges.

3.4. Food provisioning

This study found that household food security in Soweto is highly dependent on water and energy availability. The community faces high levels of food insecurity, driven by economic constraints, high food prices, and limited affordability of fresh and nutritious food. Respondents in the study reported that food was available but not affordable, as reported by one of the respondents who said, "*Food is very expensive*". The results of this study align with Nenguda and Scholes (2022), who reported a significant decline in household access (due to high costs) to food in South Africa from 2013 to 2016. This decline was attributed to rising food prices and unemployment. Similarly, in Zimbabwe and South Africa, increases in the prices of water and, especially, energy have led to higher food prices, which disproportionately affect the vulnerable and poor households in urban areas (Gulati et al., 2013; Gandidzanwa and Togo, 2023).

The disruption of water and energy supplies directly impacts food production, preparation, and preservation. This exacerbates the vulnerability of households. Urban agricultural initiatives are beneficial, but they are limited by water scarcity and the high costs of energy required for irrigation and food processing. Sub-Saharan Africa faces the highest global levels of food insecurity due to rapid population growth, heavy reliance on imported cereals, and stagnant agricultural production (Giller, 2020). A baseline survey by the African Food Security Urban Network (AFSUN) found severe food insecurity among households in low-income urban areas of Southern Africa (Matooane et al., 2025). Urban food poverty is driven by unemployment, low incomes, large

household sizes, poor living conditions, and skyrocketing food prices, among other factors (Chihambakwe et al., 2018).

Respondents in South Africa reported using various adaptive measures to address food insecurity, such as home gardening to supplement food resources, although some participants noted a lack of space for gardening. One respondent's comment was: *"We do not have space for gardening*." Home gardening serves as a problem-solving coping strategy as it helps to supplement household food supplies and address malnutrition. Community and home gardens can alleviate food insecurity (Carstens et al., 2021). Studies in Zimbabwe, Kenya, Uganda, Malawi, and Nepal have identified urban agriculture as a key livelihood strategy (Kimani-Murage et al., 2015; Tacoli, 2019; Tevera, 2023; Kanosvamhira, 2024; Kwiringira et al., 2024). However, droughts and insufficient institutional support in South Africa hinder this activity (Carstens et al., 2021). According to Sheridan et al. (2024), the costs of households without gardens increase because they must buy all their food.

The most used coping strategy was buying cheap food. One of the responses was: "*We change food brands that are expensive to cheaper ones (sic).*" Buying cheap food as a coping mechanism can have significant malnutrition consequences for families (Dlamini et al., 2023). In addition to prices, marketing and labelling can also influence consumer demand, compelling vulnerable populations to buy cheap, unhealthy, and unsustainable food (Branca et al., 2019).

Other coping mechanisms included borrowing, seeking assistance from relatives, limiting food intake, relying on food parcels, reusing oil, engaging in part-time jobs, and informal employment to supplement income. Some households reported consuming only basic staples like pap and cabbage. Nenguda and Scholes (2022), in a study in South Africa, also reported that some households resorted to borrowing food or money, skipping meals, and reducing nutrient intake.

While some residents employ problem-focused coping strategies involving practical actions or cognitive reasoning to manage resource shortages, others face significant stress when seeking alternative sources. Stress emerges when the demands of a situation exceed an individual's coping capacity (Carr and Pudrovska, 2007). Some of the options households end up adopting are emotional coping strategies. Emotion-focused coping can be positive, such as seeking emotional or moral support; however, it can be negative and can manifest as self-blame, frustration, anger, and avoidance. There is a noted association between food insecurity and mental health issues due to experiences such as skipping meals, begging, limiting portions, and sending family members elsewhere to eat (Dlamini et al., 2023).

The low-income households have to buy both water and food. Effective management of the WEF nexus requires institutional support for rain-harvesting technologies to sustain gardens and reduce dependency on grid networks. Aina et al. (2023) identified the potential for accessing water through piped systems and self-supplied groundwater in South Africa. Utilizing solar power for pumping underground water for gardening and domestic purposes can alleviate nexus challenges, easing pressure on the electricity grid and enhancing WEF synergies while reducing trade-offs.

3.5. Contribution to WEF Nexus Research

The findings contribute to theoretical advancements in WEF nexus research. The results reveal inextricable linkages in WEF issues at a household level and daily activities and needs. Even when WEF resources are

available, they may not be accessible. Stresses at the water-energy nexus are evident when regular load-shedding events severely impact the treatment and distribution of water services (Bhagwan, 2020), which threatens water security and negatively impacts food systems. Households end up being forced to purchase water or to rely on unsafe sources. Some households end up storing water as a coping mechanism (Tshililo et al., 2022). At the same time, water outages affect backyard gardening activities, yet they contribute towards food security (Sheridan et al., 2024).

Conflicts at the WEF nexus are also exposed when water-energy outages and associated costs affect food access, preparation, and storage. Masuku (2024) found out that load-shedding and lack of knowledge of water-energy conservation measures have worsened WEF challenges in South Africa. Decisions to purchase energy-efficient appliances are influenced by financial constraints, behavioral changes, consumer perceptions, and policy interventions.

Lack of affordability affects the choice of coping strategies in several ways. High energy bills and a lack of finances to buy energy-efficient gadgets result in the adoption of unclean energy sources like kerosene, charcoal, and firewood, which have negative impacts on health and the environment. As Masuku (2024) argued, not all households benefit from the Free Basic Electricity (FBE) and Free Basic Alternative Energy (FBAE) programs, and some of those that do not benefit resort to the use of these unstable fuel sources and illegal connections. Fossil fuel burning contributes to global warming, droughts, and other negative agricultural impacts, which in turn can result in food scarcity. This affects food security, food patterns, and diversity.

The usage of technologies such as efficient washing machines and refrigerators, and low-flow showerheads and nozzles, which reduce water usage, remains limited due to limited knowledge as well as financial constraints. Water and energy-efficient appliances save both water and energy (Olatunde et al., 2024). Saving energy implies reducing household expenses, achieving financial savings, and reducing poverty. Government subsidies on water and energy-efficient appliances and community sensitization in South Africa can go a long way in alleviating WEF problems.

3.6. Integrated WEF nexus policies for greening households

Integrated WEF nexus policies can significantly enhance sustainability and efficiency at a household level. Raising awareness and adopting water conservation practices saves water and reduces energy demand for water treatment and distribution. Similarly, promoting energy efficiency saves energy and lowers carbon emissions. These measures can result in financial savings, which can bolster households' food security. Taking shorter showers and use of efficient washing machines effectively reduces both water and energy usage. Although costly, efficient coping methods during power interruptions at the household level include the use of integrated renewable and alternative energy sources within smart microgrids. They also include the use of solar power to pump underground water, which alleviates pressure on the struggling electricity grid, enhances the availability of water, and, in turn, promotes food security through vegetable gardening. An integrated approach to food, energy, and water policies can stimulate synergies, positive trade-offs, and holistic approaches within the WEF nexus.

4. Conclusion

This study highlights the intricate relationships and trade-offs between WEF resources in urban households, which are faced with water supply issues and frequent power outages. The findings of the research underscore the significant challenges that arise from the nexus of WEF and reveal the consequent pronounced impacts on household food security and overall well-being. The study reveals that frequent power outages and load shedding disrupt daily activities and strain the availability of electricity for water treatment and distribution, as well as for food preparation. All this is happening within the context of rising prices of necessities. This adds pressure to vulnerable populations. The effect of unreliable water and energy supplies on cooking practices and reliance on cheaper, less nutritious foods due to economic constraints contributes to both nutritional deficiencies and heightened stress levels.

Households in the study area cope with unreliable access to essential services by employing a range of adaptive strategies, including water storage, use of alternative energy sources, and introducing modifications to their cooking and eating patterns. However, these coping mechanisms often come with unintended health and economic consequences. Adaptive measures such as home gardening are identified as valuable strategies for supplementing food resources and mitigating food insecurity. Nevertheless, these strategies are constrained by factors such as limited space, irrigation water supply/availability, and inadequate institutional support.

Overall, the study calls for a comprehensive approach to managing the WEF nexus that integrates improved infrastructure, supportive policies, and community-based initiatives. Strengthening rainwater harvesting systems, expanding access to renewable energy sources, and implementing effective social safety nets are crucial steps to enhancing resilience and ensuring sustainable access to WEF. Addressing these interconnected issues holistically is essential for improving the quality of life for urban households and reducing their vulnerability to the impacts of climate change and economic fluctuations. The research recommends enhanced institutional support and innovative solutions to address the WEF nexus challenges effectively. There is a need to explore the long-term viability of observed coping strategies. One limitation of the study is that findings run the risk of underrepresenting certain demographics (e.g., the elderly or those without internet access).

Acknowledgement

This research was supported by the National Research Foundation of South Africa (Grant Number: CSUR230529111046).

Disclaimer

The views, opinions, findings, conclusions, and recommendations expressed in this paper are strictly those of the authors and do not reflect the official position of the NRF or UNISA.

Ethical Compliance

The study was approved by the UNISA-CAES health ethics research committee in compliance with the UNISA policy on research ethics and the standard operating procedures.

Declaration on plagiarism

No part of this work was plagiarised or published elsewhere. This is the researchers' original work.

Funding

The funders had no role in study design, data collection and analysis, the decision to publish, or preparation of the manuscript.

Data Access Statement

All the relevant data are within the paper.

References

Abubakar, M., Agyemang, F.Y. and Tei, F. (2023), "The limits and impact of communication and context in implementing social interventions in a pandemic: Ghana's free water policy revisited", *Social Sciences and Humanities Open*, Vol. 7 No. 1, p.100483. https://doi.org/10.1016/j.ssaho.2023.100483

Adams, E., Stoler, J. and Adams, Y. (2020), "Water insecurity and urban poverty in the Global South: Implications for health and human biology", *American Journal of Human Biology,* Vol. 32 No.1, p. e23368. https://doi.org/10.1002/ajhb.23368

Adom, R.K., and Simatele, M.D. (2024), "Overcoming systemic and institutional challenges in policy implementation in South Africa's water sector", *Sustain. Water Resour. Manag.*, Vol. 10 No. 69. https://doi.org/10.1007/s40899-024-01040-3

Adom, R.K., Simatele, M.D. and Reid, M. (2022), "Addressing the challenges of the water-energy-food nexus program in the context of sustainable development and climate change in South Africa", *Journal of Water and Climate Change*, Vol. 13 No. 7, pp. 2761-2779. https://doi.org/10.2166/wcc.2022.099

Ahmed, I., Parikh, P., Munezero, P., Sianjase, G. and Coffman, D.M. (2023), "The impact of power outages on households in Zambia", *Economia Politica*, Vol. 40 No. 3, pp. 835-867. https://doi.org/10.1007/s40888-023-00311-0

Aina, I.V., Thiam, D.R. and Dinar, A. (2023), "Substitution of piped water and self-supplied groundwater: The case of residential water in South Africa", *Utilities Policy*, Vol. 80, p. 101480. https://doi.org/10.1016/j.jup.2022.101480

Allouche, J., Middleton, C., and Gyawali, D. (2015), "Technical veil, hidden politics: Interrogating the power linkages behind the nexus", *Water Alternatives,* Vol. 8 No. 1, pp. 610-626.

Bhagwan, J. (2020), "The severe consequences of load-shedding", *Water & Sanitation Africa,* Vol. 15 No. 2, pp.17-17.

Biggs, E.M., et al. (2015), "Sustainable Development and the Water-Energy-Food Nexus: A Perspective on Livelihoods", *Environmental Science & Policy Journal*, Vol. 54, pp. 389-397. https://doi.org/10.1016/j.envsci.2015.08.002

Blimpo, M.P. and Cosgrove-Davies, M. (2019}, "Electricity Access in Sub-Saharan Africa Uptake, Reliability, and Complementary Factors for Economic Impact", In: *Africa Development Forum Series 9,* International Bank for Reconstruction and Development; The World Bank: Washington, DC, USA. https://doi.org/10.1596/978-1-4648-1361-0

Branca, F., Lartey, A., Oenema, S., Aguayo, V., Stordalen, G.A., Richardson, R., Arvelo, M. and Afshin, A. (2019), "Transforming the food system to fight non-communicable diseases", *Bmj,* Vol. 364, p. l296. https://doi.org/10.1136/bmj.l296

Burton, T., Adlam, J., Murphy-Belcaster, M., Thompson-Robinson, M., Francis, C., Traylor, D., Anderson, E., Ricker-Boles, K. and King, S. (2020), "Stress and Coping among American Indian and Alaska Natives in the Age of COVID-19", *American Indian Culture and Research Journal*, Vol. 44 No. 2, pp. 49-70. https://doi.org/10.17953/AICRJ.44.2.BURTON

Caputo, S., Schoen, V., Specht, K., Grard, B., Blythe, C., Cohen, N., Fox-K¨amper, R., Hawes, J., Newell, J. and Ponizy, L. (2021), "Applying the food-energy-water nexus approach to urban agriculture: From FEW to FEWP (Food-Energy-Water-People)", *Urban Forestry & Urban Greening*, Vol. 58 No. 3, p. 126934. https://doi.org/10.1016/j.ufug.2020.126934

Carr, D. and Pudrovska, T. (2007), "Mid-Life and Later-Life Crises", in: *Encyclopedia of Gerontology (2007)*, 2nd edition, University of California, USA, Elsevier, pp. 175-185. https://doi.org/10.1016/B0-12-370870-2/00126-8

Carstens, G., Hay, R. and Laan, M.V.D., (2021), "Can home gardening significantly reduce food insecurity in South Africa during times of economic distress?", *South African Journal of Science,* Vol. 117 No. 9-10, pp. 1-7. https://doi.org/10.17159/sajs.2021/8730

Cheruiyot, K., Lengaram, E. and Siteleki, M. (2024), "South Africa's Energy Landscape Amidst the Crisis: Unpacking Energy Sources and Drivers with 2022 South African Census Data", *Sustainability*, Vol. 16 No. 2, p. 682. https://doi.org/10.3390/su16020682

Chihambakwe, M., Mafongoya, P. and Jiri, O. (2018), "Urban and Peri-Urban Agriculture as A Pathway to Food Security: A Review Mapping the Use of Food Sovereignty", *Challenges,* Vol. 10 No. 1, p. 6. https://doi.org/10.3390/challe10010006

Chitonge, H. (2020), "Urbanisation and the water challenge in Africa: Mapping out orders of water scarcity", *African Studies*, Vol. 79 No. 2, pp. 192-211. https://doi.org/10.1080/00020184.2020.1793662

Chiwaridzo, O.T. (2024), "Unleashing tomorrow's energy for sustainable development: Pioneering green building technologies and green tourism supply chain management in Zimbabwe's tourism sector", *Energy for Sustainable Development*, Vol. 78, No. 101382. https://doi.org/10.1016/j.esd.2024.101382

Dlamini, S.N., Craig, A., Mtintsilana, A., Mapanga, W., Du Toit, J., Ware, L.J. and Norris, S.A. (2023), "Food insecurity and coping strategies and their association with anxiety and depression: a nationally representative South African survey", *Public health nutrition,* Vol. 26 No. 4, pp. 705-715. https://doi.org/10.1017/S1368980023000186

Engelbrecht, F.A., Steinkopf, J., Padavatan, J., Midgley, G.F. (2024), 'Projections of Future Climate Change in Southern Africa and the Potential for Regional Tipping Points", In: von Maltitz, G.P., et al., *Sustainability of Southern African Ecosystems under Global Change, Springer, Cham*. *Ecological Studies*, Vol. 248. https://doi.org/10.1007/978-3-031-10948-5_7

Fatoki, O. (2020), "Factors Influencing the Purchase of Energy-efficient Appliances by young consumers in South Africa", *Foundations of Management*, Vol. 12 No. 1, pp. 151-166. https://doi.org/10.2478/fman-2020-0012

Folkman, S. and Lazarus, R. S. (1985), "If it changes it must be a process: study of emotion and coping during three stages of a college examination". *Journal of personality and social psychology,* Vol. 48 No. 1, pp. 150-170. https://doi.org/10.1037/0022-3514.48.1.150

Gandidzanwa, C.P. and Togo, M. (2023), "Household vulnerabilities at the intersection of water, energy, and food in urban Zimbabwe: A social practice perspective on seasonal variabilities", *International Journal of Development and Sustainability*, Vol. 12 No. 7, pp. 238-255.

Gao, D., Chen, A.S. and Memon, F.A. A (2024) "Systematic Review of Methods for Investigating Climate Change Impacts on Water-Energy-Food Nexus". *Water Resour Manage,* Vol. 38, pp. 1-43. https://doi.org/10.1007/s11269-023-03659-x

Giller, K.E. (2020), "The food security conundrum of sub-Saharan Africa", *Global Food Security,* Vol. 26, p. 100431. https://doi.org/10.1016/j.gfs.2020.100431

Gulati, M., Jacobs, I., Jooste, A., Naidoo, D. and Fakir, S. (2013), "The water–energy–food security nexus: Challenges and opportunities for food security in South Africa" *Aquatic Procedia*, Vol. 1, pp. 150-164. https://doi.org/10.1016/j.aqpro.2013.07.013

Hopkins, K.L., Hlongwane, K., Otwombe, K., Dietrich, J., Cheyip, M., Khanyile, N., Doherty, T. and Gray, G.E. (2019), "Demographics and health profile on precursors of non-communicable diseases in adults testing for HIV in Soweto, South Africa: A cross-sectional study", *BMJ open*, Vol. 9 No. 12, p. e030701. https://doi.org/10.1136/bmjopen-2019-030701

Hachem-Vermette, C. and Yadav, S. (2023), "Impact of power interruption on buildings and neighborhoods and potential technical and design adaptation methods", *Sustainability,* Vol. 15 No. 21, p. 15299. https://doi.org/10.3390/su152115299

Houngbonon, G.V., Le Quentrec, E. and Rubrichi, S. (2021), "Access to electricity and digital inclusion: evidence from mobile call detail records", *Humanities and Social Sciences Communications,* Vol. 8 No. 1, pp. 1-11. https://doi.org/10.1057/s41599-021-00848-0

Inglesi-Lotz, R. (2023) "Load shedding in South Africa: Another nail in income inequality" *South African Journal of Science*, Vol. 119 No. 9-10, pp. 1-4. https://doi.org/10.17159/sajs.2023/16597

Kabote, S.J. (2024), "The implication of water accessibility challenges to urban water governance in Morogoro municipality", *Tanzania. Heliyon*, Vol. 10 No. 6, p. e28194. https://doi.org/10.1016/j.heliyon.2024.e28194

Kanosvamhira, T.P. (2024), "Urban Agriculture and the Sustainability Nexus in South Africa: Past, Current, and Future Trends", *Urban Forum*, Vol. 35 No. 1, pp. 83-100. https://doi.org/10.1007/s12132-023-09480-4

Kim, J., Hagen, E., Muindi, Z, Mbonglou, G., Laituri, M. (2022), "An examination of water, sanitation, and hygiene (WASH) accessibility and opportunity in urban informal settlements during the COVID-19 pandemic: Evidence from Nairobi, Kenya", *Sci Total Environ,* Vol. 823, p. 153398. https://doi.org/10.1016/j.scitotenv.2022.153398

Kimani-Murage, E.W., Muthuri, S.K., Oti, S.O., Mutua, M.K., van de Vijver, S. and Kyobutungi, C. (2015), "Evidence of a double burden of malnutrition in urban poor settings in Nairobi, Kenya", *PLoS ONE*. Vol. 10 No. 6, p. e0129943. https://doi.org/10.1371/journal.pone.0129943

Klinger, E., (1975), "Consequences of commitment to and disengagement from incentives", *Psychological Review*, Vol. 82 No. 1, p. 1. https://doi.org/10.1037/h0076171

Kitole, F.A., Tibamanya, F.Y. and Sesabo, J.K. (2023), "Cooking energy choices in urban areas and its implications on poverty reduction", *International Journal of Sustainable Energy*, Vol. 42 No.1, pp. 474-489. https://doi.org/10.1080/14786451.2023.2208680

Kumpel, E., Billava, N., Nayak, N. and Ercumen, A. (2021), "Water use behaviors and water access in intermittent and continuous water supply areas during the COVID-19 pandemic" *Journal of Water and Health,* Vol. 20 No. 1, p. 139. https://doi.org/10.2166/wh.2021.184

Kwiringira, J., Mohling, E.W.P., Mathias, A., Ariho, P., Mugisha, J., Zakumumpa, H., Rujumba, J. and Tumwebaze, I.K. (2024), Urban agriculture as an evolved sustainable urban livelihood: evidence from Kampala city, Uganda, *Agriculture & Food Security*, Vol. 13 No. 1, p. 53. https://doi.org/10.1186/s40066-024-00507-y

Lazarus, R.S. and Folkman, S. (1987), Transactional theory and research on emotions and coping, *European Journal of Personality*, 1(3), 141-169. https://doi.org/10.1002/per.2410010304

Li, H., Cohen, A., Li, Z., Lv, S., He, Z., Wang, L., Zhang, X. (2020), "Intermittent Water Supply Management, Household Adaptation, and Drinking Water Quality: A Comparative Study in Two Chinese Provinces", *Water,* Vol. 12 No.5, p1361. https://doi.org/10.3390/w12051361

Makonese, T., Ifegbesan, A.P. and Rampedi, I.T. (2017), "Household cooking fuel use patterns and determinants across southern Africa: Evidence from the demographic and health survey data", *Energy & Environment*, Vol. 29 No. 1, pp. 29-48. https://doi.org/10.1177/0958305X17739475

Mmakwena, M. (2022), "An evaluation of the impact of cable theft on the free flow of traffic in South Africa", *Research in Business & Social Science, IJRBS,* Vol. 11 No. 6, pp. 542-551. https://doi.org/10.20525/ijrbs.v11i6.1968

Mashabela, K., Dube, T., Mollel, M.H., Letsoalo, J.M and Radingoana, M.P. (2022), "Assessing accessibility and availability of portable water supply in selected communities of Lepelle-Nkumpi local municipality, Limpopo province of South Africa", *Physics and Chemistry of the Earth, Parts A/B/C*, Vol. 127 No. 2, p. 103181. https://doi.org/10.1016/j.pce.2022.103181

Masuku, B. (2024), "Rethinking South Africa's household energy poverty through the lens of off-grid energy transition", *Development Southern Africa*, Vol, 41 No. 2 pp. 1-24. https://doi.org/10.1080/0376835X.2023.2300411

Matooane, L.S., Matamanda, A., Bhanye, J. et al. (2025), "The Role of Urban Planning in Strengthening Urban Food Security in Africa: Insights from Lesotho, Zimbabwe and South Africa", *Urban Forum*. https://doi.org/10.1007/s12132-024-09530-5

Mazenda, A., Molepo, N., Mushayanyama, T. and Ngarava, S. (2022), "The invisible crisis: the determinants of local food insecurity in Gauteng municipalities, South Africa", *British food journal*, Vol. 124 No. 13, pp. 274-289. https://doi.org/10.1108/BFJ-11-2021-1234

Megbowon, E., Mukarumbwa, P., Ojo, S. and Olalekan, O.S. (2018), "Household cooking energy situation in Nigeria: Insight from Nigeria Malaria Indicator Survey 2015", *International Journal of Energy Economics and Policy*, Vol. 8 No. 6 pp. 284-291.

Mguni, P., van Vliet, B., Spaargaren, G., Nakirya, D., Osuret, J., Isunju, J.B., Ssekamatte, T. and Mugambe, R.K. (2020), "What could go wrong with cooking? Exploring vulnerability at the water, energy and food Nexus in Kampala through a social practices' lens", *Global Environmental Change-human and Policy Dimensions*, Vol. 63, p. 102086. https://doi.org/10.1016/j.gloenvcha.2020.102086

Mohlakoana, N., de Groot, J., Knox,. A. and Bressers, H. (2019), "Determinants of energy use in the informal food sector", *Development Southern Africa*, Vol. 36 No. 4, pp. 476-490. https://doi.org/10.1080/0376835X.2018.1526059

Mpandeli, S., Naidoo, D., Mabhaudhi, T., Nhemachena, C., Nhamo, L., Liphadzi, S., Hlahla, S. and Modi, A.T. (2018), "Climate change adaptation through the water-energy-food nexus in Southern Africa", *Int. J. Environ. Res. Public Health*, Vol. 15 No. 10, p. 2306. https://doi.org/10.3390/ijerph15102306

Muazu, N. (2020), "Energy and Development: A review of the Challenges in Household Energy Usage in Nigeria and South Africa", *Journal of Science Technology and education*, Vol. 8 No. 3, pp. 184-194.

Mukoma, G., Bosire, E.N., Klingberg, S. and Norris, S.A. (2023), "Healthy eating and physical activity: analysing Soweto's young adults' perspectives with an intersectionality lens", *PLOS Global Public Health*, Vol. 3 No. 7, p. e0001429. https://doi.org/10.1371/journal.pgph.0001429

Murwirapachena, G. (2021), "Understanding household water-use behaviour in the city of Johannesburg, South Africa", *Water Policy*, Vol. 23 No. 5, pp. 1266-1283. https://doi.org/10.2166/wp.2021.157

Ndlovu, C., and Masuku, M.M. (2024), Half A Loaf is Better Than None: Social Relief Distress Grant Challenges and Benefits to Enhance Food Security, *Journal of Law and Sustainable Development*, Vol. 12 No. 1, p. e1616. https://doi.org/10.55908/sdgs.v12i1.1616

Nenguda, R. and Scholes, M.C. (2022), "Appreciating the resilience and stability found in heterogeneity: A South African perspective on urban household food security", *Frontiers in Sustainable Food Systems*, Vol. 6, p. 721849. https://doi.org/10.3389/fsufs.2022.721849

Ningi, Thulani and Taruvinga, Amon and Zhou, Leocadia and Ngarava, Saul, (2021), "Factors that influence household food security in Hamburg and Melani, Eastern Cape, South Africa", *African Journal of Science, Technology, Innovation and Development*. Vol. 14 No. 1, pp1-9. https://doi.org/10.1080/20421338.2021.1927467

Njoroge, P., Ambole, A., Githira, D. and Outa, G. (2020), "Steering Energy Transitions through Landscape Governance: Case of Mathare Informal Settlement, Nairobi, Kenya". *Land,* Vol. 9 No. 6, p. 206. https://doi.org/10.3390/land9060206

Nkosi, N.C., Burger, R.P., Matandirotya, N.R., Pauw, C. and Piketh, S.J. (2021), "Solid fuel use in electrified low-income residential areas in South Africa: The case of KwaDela, Mpumalanga", *Journal of Energy in Southern Africa*, Vol. 32 No.1, pp. 58-67. https://doi.org/10.17159/2413-3051/2021/v32i1a8086

Ogujiuba1, K. and Muazu, N. (2022), "Unclean Energy Source Dependence and Sustainability in Nigeria: Consumption Dynamics and Impact of Contextual Factors", *International Journal of Energy Economics and Policy*, Vol. 12 No. 6, pp. 495-504. https://doi.org/10.32479/ijeep.13663

Olatunde, T., Okwandu, A. and Akande, D. (2024), "Reviewing the impact of energy-efficient appliances on household consumption", *International Journal of Science and Technology Research Archive,* Vol. 6 No. 2, pp. 001-011. https://doi.org/10.53771/ijstra.2024.6.2.0038

Oyekale, A.S. and Molelekoa, T.C. (2023), "Multidimensional Indicator of Energy Poverty in South Africa Using the Fuzzy Set Approach", *Energies,* Vol. 16 No. 5, p. 2089. https://doi.org/10.3390/en16052089

Oyerinde, A.O. and Jacobs, H.E. (2022), "The complex nature of household water supply: an evidence-based assessment of urban water access in Southwest Nigeria", *Journal of Water, Sanitation and Hygiene for Development* Vol. 12 No. 3, pp. 237-247. https://doi.org/10.2166/washdev.2022.176

Oskam, M.J., Pavlova, M., Hongoro, C. and Groot, W. (2021), "Socio-economic inequalities in access to drinking water among inhabitants of informal settlements in South Africa", *International Journal of Environmental Research and Public Health,* Vol. 18 No. 19, p. 10528. https://doi.org/10.3390/ijerph181910528

Perros T, Allison A L, Tomei J, Aketch V, and Parikh P (2023), "Cleaning up the stack: Evaluating a clean cooking fuel stacking intervention in urban Kenya", *Renewable and Sustainable Energy Reviews,* Vol. 188, p. 113900. https://doi.org/10.1016/j.rser.2023.113900

Phogole, B., Kelso, C. and Langerman, K.E. (2022), "The effectiveness of household energy transition interventions in a coal-using community on the South African Highveld", *Energy for Sustainable Development,* Vol. 71, pp. 1-12. https://doi.org/10.1016/j.esd.2022.09.006

Price, E.A. C., White, R. M., Mori, K., Longhurst, J., Baughan, P., Hayles, C.S., Gough G., and Preist, C. (2021), "Supporting the role of universities in leading individual and societal transformation through education for sustainable development. Case Study", *Discover Sustainability* Vol. 2 No. 49. https://doi.org/10.1007/s43621-021-00058-3

Rai, P.K. (2023), "Role of water-energy-food nexus in environmental management and climate action", *Energy Nexus,* Vol. 11 No. 3, p. 100230. https://doi.org/10.1016/j.nexus.2023.100230

Sheridan C. (2024), "Water insecurity in Johannesburg (and beyond?)", *S Afr J Sci*, Vol. 120 No. 19068, pp. 11-12. https://doi.org/10.17159/sajs.2024/19068

Simelane, T., Chikozho, C., Mutanga, S.S., Managa, L.F., Tshililo, F. and Dabata, T., (2021), "Status of water security in inland South African cities". *Journal of Digital Food, Energy & Water Systems*, Vol. 1 No. 1, pp. 34-64. https://doi.org/10.36615/digitalfoodenergywatersystems.v1i1.411

Simpson, G.B., Jewitt, G.P., Mabhaudhi, T., Taguta, C. and Badenhorst, J., (2023), "An African perspective on the water-energy-food nexus", *Scientific Reports*, Vol. 13 No. 1, p. 16842. https://doi.org/10.1038/s41598-023-43606-9

Tshililo, F., Mutanga, S., Sikhwivhilu, K., Siame, J., Hongoro, C., Managa, L., Mbohwa, C. and Madyira, D. (2022), "Analysis of the determinants of household's water access and payments among the urban poor. A case study of Diepsloot Township", *Physics and Chemistry of the Earth, Parts A/B/C*, Vol. 127 No. 103183. https://doi.org/10.1016/j.pce.2022.103183

Tacoli, C. (2019), "The urbanization of food insecurity and malnutrition". *Environment & Urbanization*, Vol. 31 No. 2, pp. 371-374. https://doi.org/10.1177/0956247819867255

Tevera, D. (2023), "Secondary Cities and Urban Agriculture in Sub-Saharan Africa", In: Riley, L., Crush, J. (eds), *Transforming Urban Food Systems in Secondary Cities in Africa*, Palgrave Macmillan, Cham, pp. 133-147. https://doi.org/10.1007/978-3-030-93072-1_7

Toole, S., Klocker, N. and Head, L. (2016), "Re-thinking climate change adaptation and capacities at the household scale", *Climatic Change: Springer*, Vol. 135 No. 2, pp. 203-209. https://doi.org/10.1007/s10584-015-1577-x

Tucho, G.T., Deti, M., Dadi, D. and Teshome, T. (2022), "Urban Households' Biomass Energy Fuel Stacking and Its Implications for Sustainable Development Goal Seven: The Case of Jimma Town, Ethiopia", *Global Challenges*, Vol. 6 No. 5, p. 2100154. https://doi.org/10.1002/gch2.202100154

Tumwebaze, I.K., Sseviiri, H., Bateganya, F.H., Twesige, J., Scott, R., Kayaga, S., Kulabako, R. and Howard, G., (2023), "Access to and factors influencing drinking water and sanitation service levels in informal settlements: Evidence from Kampala, Uganda", Habitat International, 136, p. 102829. https://doi.org/10.1016/j.habitatint.2023.102829

UNICEF (2017), "Progress on Drinking Water, Sanitation and Hygiene: Update and SDG Baselines", Launch version July 12 Main Report; 2017.

Vérez, D., Borri, E., Cabeza, L.F. (2022), "Trends in Research on Energy Efficiency in Appliances and Correlations with Energy Policies", *Energies,* Vol. 15 No. 9, p. 3047. https://doi.org/10.3390/en15093047

Vidhyadharan, A. (2023), "Disparities in Drinking Water and Sanitation in the Urban Slums of Kerala, India", *Sustainability,* Vol. 15 No. 9, p. 7559. https://doi.org/10.3390/su15097559

Wernecke, B., Langerman, K.E., Howard, A.L., Wright, C.Y. (2024), "Fuel switching and energy stacking in low-income households in South Africa: A review with recommendations for household air pollution exposure research*" Clean Air J.,* Vol. 34 No. 1, p. 1. https://doi.org/10.17159/caj/2024/34/1.18555

WHO/UNICEF (2015), "Joint Water Supply and Sanitation Monitoring Programme. Progress on sanitation and drinking water: 2015 update and MDG assessment", World Health Organization.

World Health Organization, United Nations Children's Fund (UNICEF) (2017), "Progress on drinking water, sanitation, and hygiene: 2017 update and SDG baselines. World Health Organization License: CC BY-NC-SA 3.0 IGO", available at: https://apps.who.int/iris/handle/10665/258617 (Accessed 26 Feb. 2025).

Zyoud, S. (2022), "Mapping and Visualizing Global Knowledge on Intermittent Water Supply Systems", *Water*, Vol. 14 No. 5, p. 738. https://doi.org/10.3390/w14050738